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Generic Ordnance Ramjet Engine (GORJE) Fuel Tank, Final Report

by
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Chemical Systems Division—United Technologies
for the
Propulsion Development Department

OCTOBER 1976

Naval Weapons Center
CHINA LAKE, CALIFORNIA 93555

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FOREWORD

This report describes work conducted during the period July 1974 to January 1976 on the design, analysis, fabrication, testing and delivery of positive expulsion fuel tank assemblies for the generic ordnance ramjet engine (GORJE). This effort was sponsored by the Naval Weapons Center (NWC), China Lake, California, under Navy Contract N00123-74-C-1357 and supported by the Naval Air Systems Command under AirTask A3303300/008B/4F31334300.

B. Waldon was the Navy Technical Coordinator and has reviewed this report for technical accuracy.

This report is released for information at the working level and does not necessarily reflect the views of NWC.

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(U) *Generic Ordnance Ramjet Engine (GORJE) Fuel Tank, Final Report*, by T. C. Warren, Chemical Systems Division. China Lake, Calif., NWC, October 1976. 210 pp. (NWC TP 5835, publication UNCLASSIFIED.)

(U) This report discusses the design, analysis, fabrication, testing, and delivery of positive expulsion fuel tank assemblies for the generic ordnance ramjet engine (GORJE). The program was conducted in two phases: Phase I Task I encompassed the design and analysis of a tank assembly satisfying the basic GORJE requirements. This assembly consisted of a 4130 steel tank with a reinforced elastomeric positive expulsion bladder that contains the ramjet fuel and collapses around a central collector pipe that houses the fuel delivery gas generator and flow control valve. Phase I Task II involved the fabrication and test of one ground test tank with a spare collector pipe and six expulsion bladders. This ground test tank was delivered to NWC for testing purposes.

(U) Phase II involved the fabrication, checkout, and delivery of four flight test units to NWC for use in the GORJE flight test program.

(U) This program was concluded with a detailed manufacturing cost analysis of the tank assembly in quantities up to 2,000 units.

CONTENTS

Appendixes

ACRONYMS

ASTM	American Society for Testing Materials
CRES	Corrosion resistant steel
CSD	Chemical Systems Division
GTA	Gas tungsten arc
MPI	Magnetic particle inspection
NASA	National Aeronautics and Space Administration
NASTRAN	National Aeronautics and Space Administration Structural Analysis Code (computer program)
NWC	Naval Weapons Center
SS	Stainless steel
STAGS	Static Shell Analysis Code (computer program)
TDC	Top dead center

NOMENCLATURE

C_{L_α}	Lift curve slope for forebody (radians)$^{-1}$
d	Diameter of body (feet)
F	Force (pounds)
f	Ratio of $\ell E/d$
H	Altitude (feet)
ℓ_B	Length of body (feet)
M	Mach number
q	Maximum dynamic pressure (pounds/square feet)
S_o	Forebody cross-sectional area at station 0
S_x	Forebody cross-sectional area (square feet)
x	Forebody length (feet)
x_m	Location of moment center (feet)
x_o	Forebody length at station 0 (feet)
V_B	Volume of body (cubic inches)
σ_A	Axial stress (psi)
σ_H	Hoop stress (psi)
σ_R	Radial stress (psi)

Subscripts

su	Ultimate compression
tu	Tensile ultimate
ty	Tensile yield

1
INTRODUCTION

This program was conducted to analyze, design, manufacture, test, document, and deliver five Generic Ordnance Ramjet Engine (GORJE) fuel tank assemblies including fuel tank, containment and expulsion device (bladder), and collector pipe assembly.

The program was divided into two phases. Phase I included as concurrent tasks: (1) analysis and design of fuel tank assemblies; and (2) design, manufacture, test, and delivery of one ground test unit. Phase II consisted of manufacture, test, and delivery of four flight test assemblies.

The program began on 10 July 1974 and was completed on 31 December 1975. This report describes the program design activities during that period.

The 47.5-pound ground test unit design described in this report, which was fabricated and delivered under Phase I, Task 2, is identical to the flight test unit design that was fabricated and delivered during Phase II of this program.

This final report covers the design, analysis, and manufacturing of the tanks, testing conditions and results, and the final manufacturing cost analysis.

2
FUEL TANK DESIGN OBJECTIVES

The primary design objective was to design and analyze GORJE fuel tank assemblies which satisfied requirements and constraints specified in the Appendix A data package.

This report contains a design description, a structural analysis, and a manufacturing cost analysis. The complete preferred design description includes engineering drawings, method of manufacture, rationale for the design of all components, materials, weight estimates, fuel volume estimates, and expulsion efficiency estimates.

A detailed structural analysis of the fuel tank was conducted. A detailed manufacturing cost analysis (up to 2,000 units) includes the following cost comparisons used to arrive at the preferred design: (1) bladder cost versus expulsion efficiency (2) tank internal volume versus tank cost and (3) tank weight versus cost. The cost analysis employed design-to-cost information.

3
GORJE FUEL TANK ASSEMBLY DESIGN DESCRIPTION

TANK ASSEMBLY

The GORJE fuel tank assembly (CSD drawing No. C11225) consists of four major subassemblies: (1) tank pressure case and structure, (2) removable suspension lug assembly, (3) reinforced elastomeric expulsion bladder, and (4) fuel collector pipe.

The same tank assembly design was used for both the ground test unit and the four flight test units. This configuration, excluding bladder and collector pipe, weighs 47.5 pounds compared to a ground test unit maximum allowable weight of 51 pounds and a flightweight design goal of 44 pounds. The proposed methods of reducing the current 47.5-pound tank to the 44-pound flightweight production configuration are discussed in this section.

Figure 3-1 is a complete block diagram for the tank assembly. Assembly and component drawings are presented in Appendix B.

Photographs of the ground test unit tank are shown in Figs. 3-2 through 3-5.

Tank Structure (Design Approach)

Detailed trade studies were conducted which resulted in selection of a baseline design that meets all NWC requirements and constraints specified in the GORJE Fuel Tank Assembly Data Package (Appendix A). The design-to-cost disciplines were implemented by appointing a component cost targeting board which established baseline component cost estimates in coordination with the cost engineering team. These estimates were used during the integrated trade studies of candidate designs.

Two basic design approaches were investigated. The first approach allowed the pressure tank to share the captive flight and ejection loads with the suspension lug attach support structure. The second approach was to separate the fuel tank into two structural elements: (1) a pressure vessel to provide the required volume and support for the bladder, and (2) a suspension lug attach structure to react captive and ejection loads.

The latter approach resulted in a lower weight and lower cost design. Further weight reductions that were investigated are possible at increased costs. The key design features of the fuel tank structure include: (1) low cost 4130 steel components, (2) roll and weld construction, (3) separate structural components for reacting concentrated loads, and (4) removable suspension lug assemblies.

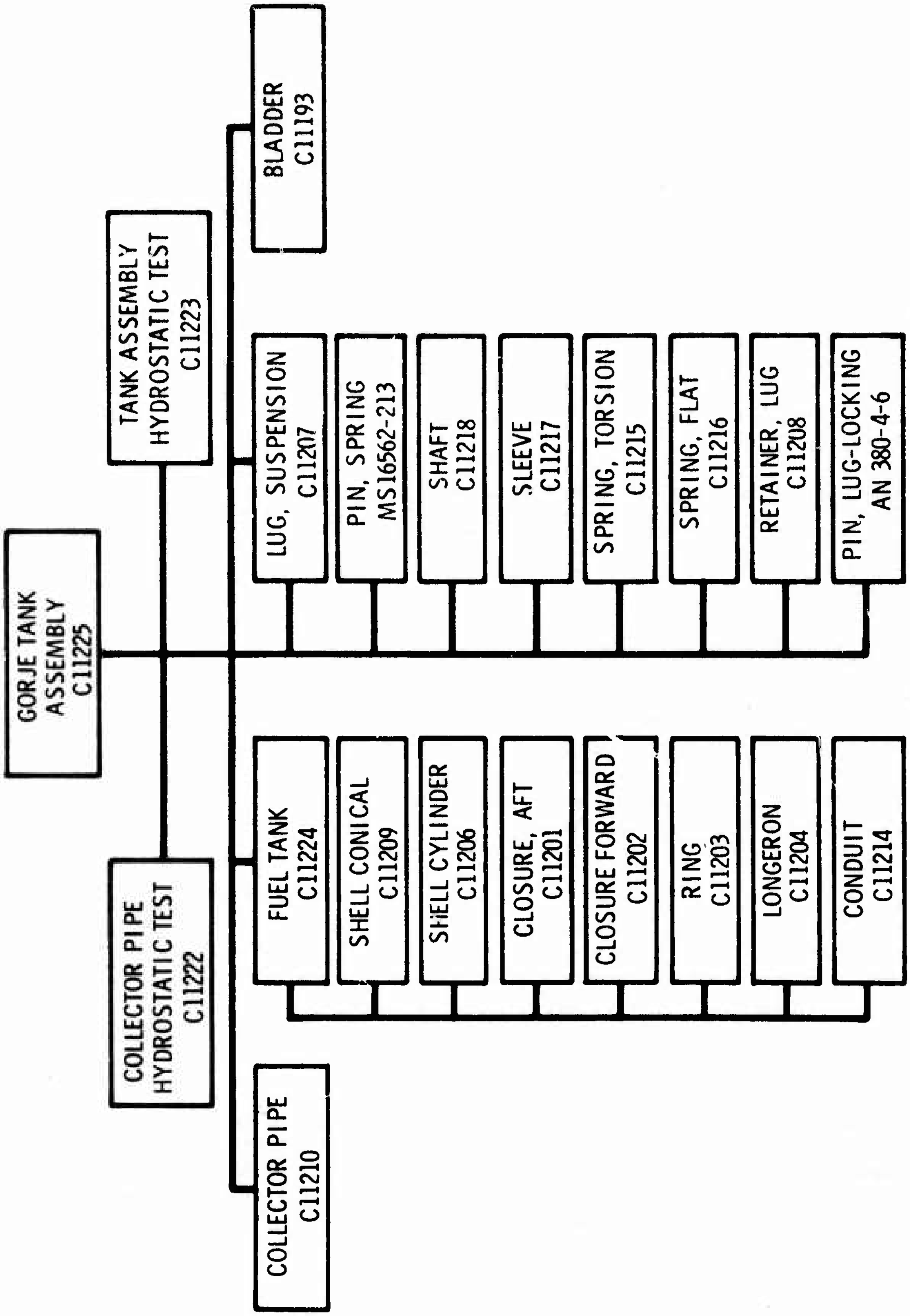


FIG. 3-1. Component Block Diagram for the Tank Assembly.

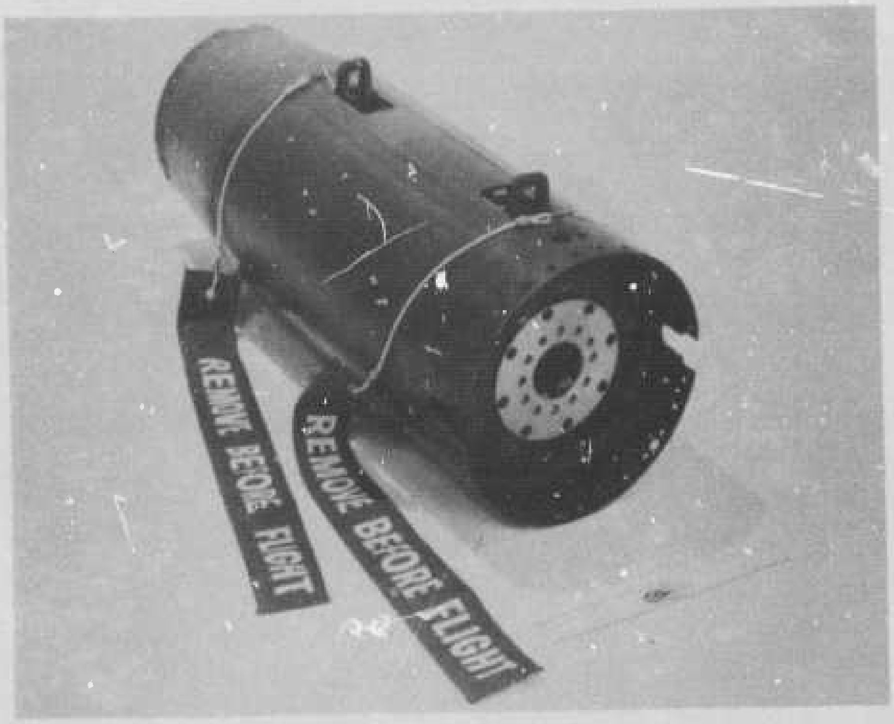


FIG. 3-2. Fuel Tank Assembly
with Bladder and Collector Pipe Installed.

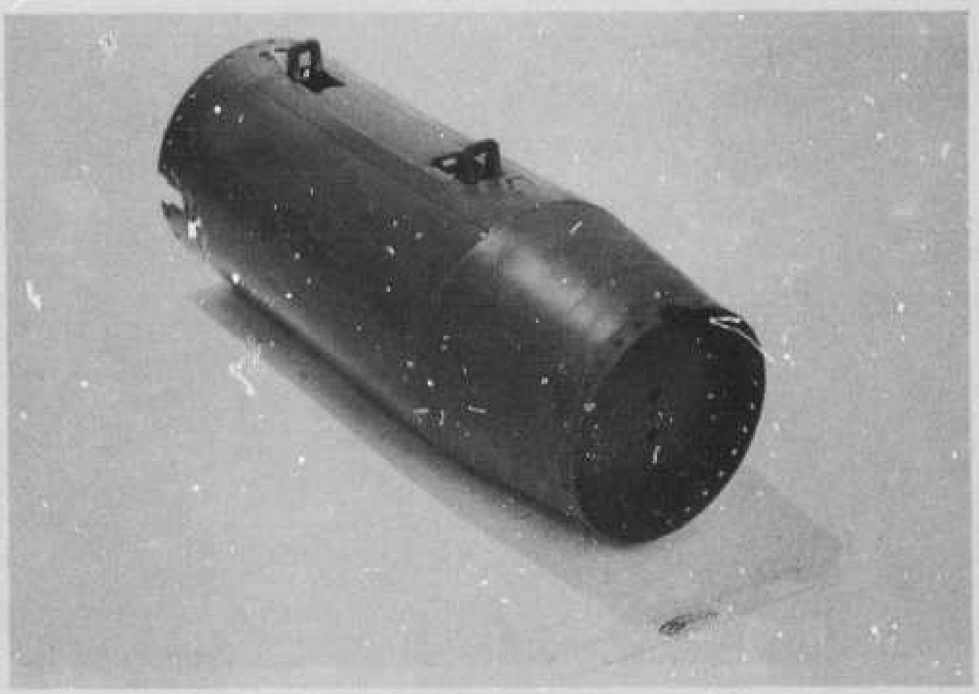


FIG. 3-3. Fuel Tank Assembly Showing Forward Closure.

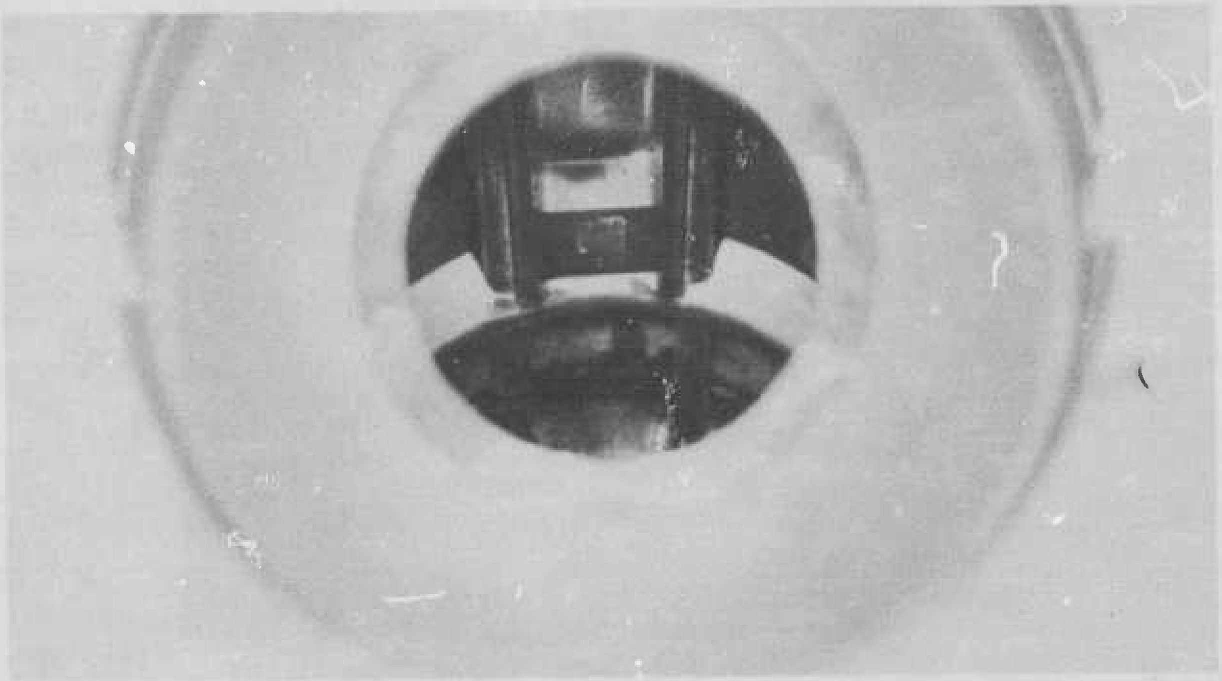


FIG. 3-4. Fuel Tank Showing Internal Sway Brace Ring and Longeron.

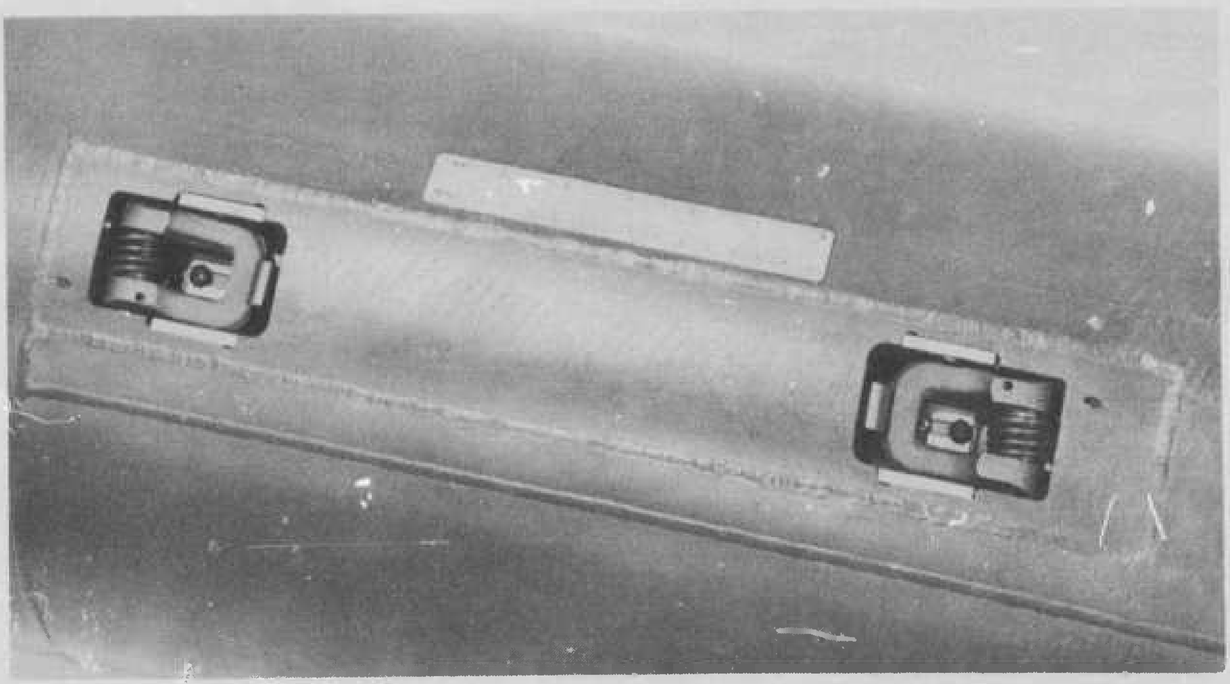


FIG. 3-5. Fuel Tank Assembly Showing Suspension Lugs in Retracted Position.

Design Description

The GORJE fuel tank assembly is shown in Appendix B, Fig. B-1. This configuration meets all requirements shown in Table 3-1.

FUEL TANK CASE

The tank is a five-component weldment consisting of forward and aft closures, two-piece cylindrical center section, and a conical fore-body. The tank case functions to provide the required internal volume and to support the fuel bladder. In addition, both closures have skirt flanges which include provisions for all specified attachments. Two 0.63-inch-diameter raceway tubes penetrate the closures and pass through the tank interior to connect the skirt areas. The forward closure has an internal boss which provides lateral support for the forward end of the collector pipe assembly and contains vent holes through which the expulsion gas is admitted to the space between the tank interior and bladder to initiate bladder collapse. The forward closure also has seven externally mounted bosses which provide attachment for flight instrumentation. The closure also has three ports in the center for the gas generator igniter, pressure relief valve, and instrumentation.

TABLE 3-1. Requirements and Constraints.

Envelope constraints.	NWC Drawing No. SK45760004
Fuel volume, lb	75 (minimum)
Weight, lb.	44 (maximum) flight production design
. . . .	51 (maximum) ground test design
External loads.	Fig. A-3 of Appendix A
Vibration	Fig. A-3 of Appendix A
Factor of safety	
All point loads.	1.5 on ultimate
. . . .	1.15 on yield
Pressure, psi	
Proof.	450
Yield.	475
Ultimate	550
Temperature, °F	
Storage.	-45 to 140
Flight	550 (internal)

The conical forebody is a 0.062-inch-thick roll and welded frustum of a right circular cone. It provides the necessary transition between the 10-inch-OD forward closure attach skirt and the 12-inch-OD tank cylindrical centerbody.

The centerbody is a two-piece cylinder consisting of a 0.062-inch-thick roll-formed cylindrical section 315 degrees in arc length into which a thickened (0.093-inch) roll-formed section with an arc length of 45 degrees has been inserted. Two longitudinal welds attach the two pieces to form the complete cylinder. The thickened skin section was added to provide the required stress distribution in the cylinder in the area of attachment to the longeron assembly. The thickened skin has a cutout into which the longeron is welded at final assembly.

The aft closure is welded to the cylindrical centerbody to complete the tank. The closure includes an integral skirt with attachment provision and an opening and attachment bolt hole pattern for securing the aft end of the collector pipe/bladder assembly. The Y joint of the closure acts as a part of the structure which reacts the concentrated loads introduced by the aft sway brace units. The closure has slots and holes in the skirt for tank fill, vent valves, and fuel transfer lines.

All components of the tank case are fabricated from 4130A steel per MIL-S-18729. The forward closure is annealed, the conical and cylindrical shells are normalized, and the aft closure is heat treated to 140,000 to 160,000 psi minimum ultimate tensile strength.

To minimize overall costs, the suspension lug, sway brace, and ejection concentrated loads on the tank are carried by a reinforcement structure which acts independently from the basic case wall. The structure includes a forward sway brace stiffener ring, longeron, and an aft sway brace stiffener ring, which consists of the thickened area of the aft closure Y joint.

The support ring and longeron include webs at load application points to react concentrated loads. The longeron also includes integral suspension lug housings. U-shaped cross sections are selected for both units to give structural efficiency in bending while minimizing fabrication cost and weight.

SUSPENSION LUGS

Replaceable retracting suspension lugs are housed in the longeron. (See Fig. 3-6.) The lugs are forged of 4340 steel and machined. The force required to restore each of the vehicle attachment lugs to its recessed position during vehicle flight is provided by a high-strength steel torsion spring. Each spring exerts a torque of 28 inch-pounds when the lug is rotated for attachment of the vehicle to the aircraft. This torque is sufficient to overcome frictional drag and inertial forces acting on the lug and will rotate the lug into the recess provided in the longeron. Once down, the lug is secured in position by a flat

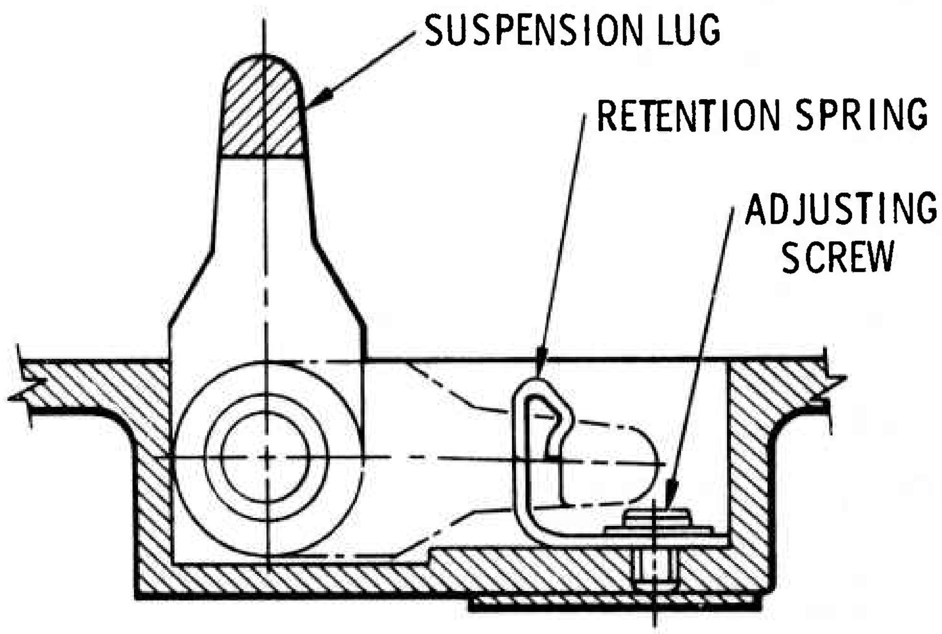


FIG. 3-6. Suspension Lug Retention System.

steel spring which engages the lug crossbar. This prevents rerotation of the lug back into the airstream.

The adjustment of the flat spring is performed by loosening the adjustment screw and shifting the flat spring until contact is made with the lug with interference of 0.03 to 0.06 inch. This approach (low-torque torsion spring, securing spring) was selected because it was found to be impractical to design a spring to meet the alternative requirement (250 inch-pounds of torque).

A pullpin is also provided which passes through the strongback wall and into the lug to hold the lug in the upright position during mounting on the aircraft. This pin is removed following mounting.

The suspension lug subassembly, consisting of lug, shaft, sleeve, and spring, can easily be removed for maintenance and/or replacement. The two retainer plates are unbolted and the lug assembly is slid out of the slots in the pocket sidewall.

The lug shaft has flats which interface with the top lip on the slot. This feature provides added bearing area on the shaft and increased shear area to the slot lip.

The shaft sleeve stabilizes the torsion spring in the loaded position.

FUEL EXPULSION BLADDER ASSEMBLY

The tank requires a bladder to ensure positive fuel expulsion for all attitudes and operational environments and to separate the expulsion gas from the fuel. A reinforced elastomeric bladder which collapses around the fuel collector pipe is the baseline design for this application.

Bladder Design

Design considerations for the positive expulsion bladder were as follows: (1) low cost, (2) reliability, (3) expulsion efficiency, (4) weight and volume, (5) compatibility with the propellant (long term storage), (6) permeability, (7) low temperature and high temperature operating characteristics, (8) multiple cycle life, and (9) ease of installation in tank assembly.

Design Approach

The baseline bladder design is shown in Appendix B, Fig. B-2, and a photograph of the expanded bladder attached to the collector pipe is shown in Fig. 3-7. The bladder provides multiple cycle capability to permit expulsion testing for acceptance and for demonstration of reliability for single cycle use.

Evaluation of the design requirements led to the selection of a nylon fabric reinforced nitrile laminate elastomer bladder (Goodyear BTC 17-4). The propellant is contained within the bladder and discharged through the collector pipe as the bladder collapses around the pipe during expulsion. The bladder is attached at each end of the collector pipe by metallic rings vulcanized to the ends of the bladder. The bladder is contoured to assume the internal shape of the pressure vessel. Depressions are incorporated in the structure to accommodate the strongback, electrical raceways and sway brace stiffener ring which protrude into the tank. This geometry minimizes membrane bridging and reduces bladder stresses. Basic thickness of the bladder is 0.020 inch. External strips are located at 60-degree intervals on the bladder exterior so that the bladder can be fully expanded in the pressure case without air entrapment between case and bladder. Reinforcement is added at the attach rings located at the bladder poles to accommodate the higher stress loads.

The aft end bladder flange consists of the bladder vulcanized between two stainless steel compression rings. This flange is bolted to the aft flange of the fuel collector pipe assembly with 12 4-40 screws, as shown in Fig. B-1 in Appendix B. The attach bolts are installed from outside of the tank, pass through the collector pipe flange, and screw into the outer compression collar. Leakage from either the bladder interior to exterior or through the flange bolt holes is prevented by O-ring seals on both the inner edge of the bladder flange and under the flange bolt heads. The nonuniform spacing of the bolt hole pattern keeps the bladder in position so its shape conforms with the tank interior configuration.

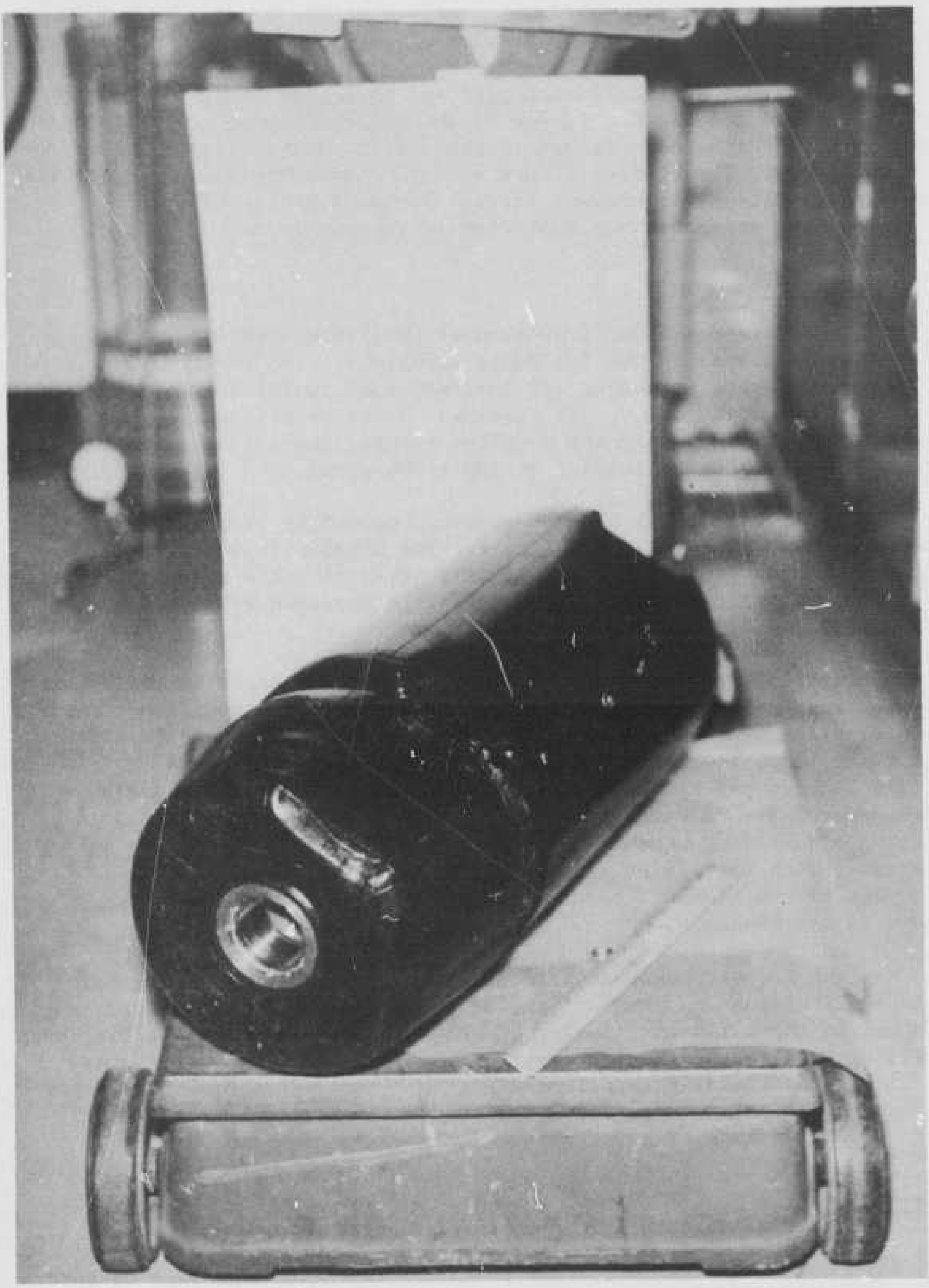


FIG. 3-7. Expanded Bladder Assembly
as Attached to Collector Pipe.

The bladder forward end flange consists of the bladder vulcanized between two stainless steel compression rings using the same technique applied to the aft flange. The outer compression ring slides over the forward end of the fuel collector pipe and is sealed by an O-ring compressed between the bladder flange ID and collector pipe OD (Fig. B-1, Appendix B). The bladder flange is attached to the collector pipe with 12 4-40 screws. The bladder flange also fits over the collar inside the tank forward closure to prevent lateral movement of the bladder/collector pipe assembly when installed in the tank.

Bladder Analysis

The stresses resulting from bladder operation with the baseline design can be placed in the following categories: (1) internal load caused by propellant vapor pressure, (2) internal load caused by axial and lateral acceleration and vibration, (3) stresses caused by bridging when the bladder is partially empty and sloshing occurs, and (4) stresses caused by small radius bladder folding at low temperature.

The maximum internal bladder pressure caused by propellant vapor pressure at 140°F is less than 1 psia. The bladder is designed to be supported by the pressure case including areas of cable raceways, stiffener ring, and strongback. Therefore, negligible stresses will be induced during storage.

Vibration is not expected to cause appreciable loads in the bladder because frequencies are above 20 Hz and high frequencies will not cause damaging propellant sloshing. Captive flight may induce accelerations as high as 15 g, resulting in sloshing pressures as high as 15 psi axially and 6.5 psi radially. These pressures are not excessive even if the bladder fails to match the contour of the tank interior and localized bridging occurs. (Subsequent testing of bladders pressurized to 50 psi internally with the cavity between bladder and case vented resulted in no damage to the bladder, even when the bladder was incorrectly positioned in the case.)

Maximum bladder membrane bending occurs in the folds during hard collapse expulsion (maximum ΔP) and at the poles where the bladder is attached to the collector pipes. The bladder material selected precludes a folding problem and reinforcement is used at the polar bosses where failures were initially experienced during bladder development on other programs. The polar compression collars are contoured to prevent a sharp fold at points of attachment.

Bladder Material Selection

The requirements of the GORJE bladder present an extension of current technology with TH-Dimer fuel and elastomer bladders with respect to expulsion gas temperatures, operational pressures, and configuration. A review of available data supported the initial selection of Goodyear BTC 17-4, a nitrile/nylon laminate, as the bladder material. It is a

composite construction consisting of an 0.003-inch film of nylon sandwiched between single layers of nitrile coated, 2-ounce nylon fabric. The nylon is the impermeable barrier to the fuel and the fabric contributes to the structural, handling, and bonding characteristics of the bladder.

COLLECTOR PIPE ASSEMBLY

The GORJE fuel tank collector pipe assembly contains the tank pressurization gas generator and fuel controller. It also serves as the attachment point for the positive expulsion bladder, collects the fuel through radial holes, and delivers it to the fuel controller.

Design

The collector pipe assembly was designed to meet the requirements of Appendix A. The corresponding CSD design is shown in Fig. B-11 of Appendix B. The assembly, including bladder flanges, was fabricated of CRES 304. The aft flange was designed to fit a 5-inch-diameter opening in the end of the fuel tank. This opening is controlled by the space required for bladder installation. (The bladder attachment was described earlier in this section). Internal geometry of the collector pipe will accept the gas generator and fuel controller valve assemblies. The ground test unit collector pipe is shown in Fig. 3-8.

Structural Analysis

The structural analysis of the collector pipe is an integral part of the analysis of the tank as a whole. The loads and failure modes considered for the collector pipe are stress and buckling forces due to inertial forces, and sloshing and bending stresses at the bolted flange. The modeling of the collector pipe in the general models of the assembled tank is in sufficient detail to give accurate solutions for stresses and displacements. The solutions for stresses and displacements, therefore, come from the solutions for the assembled tank.

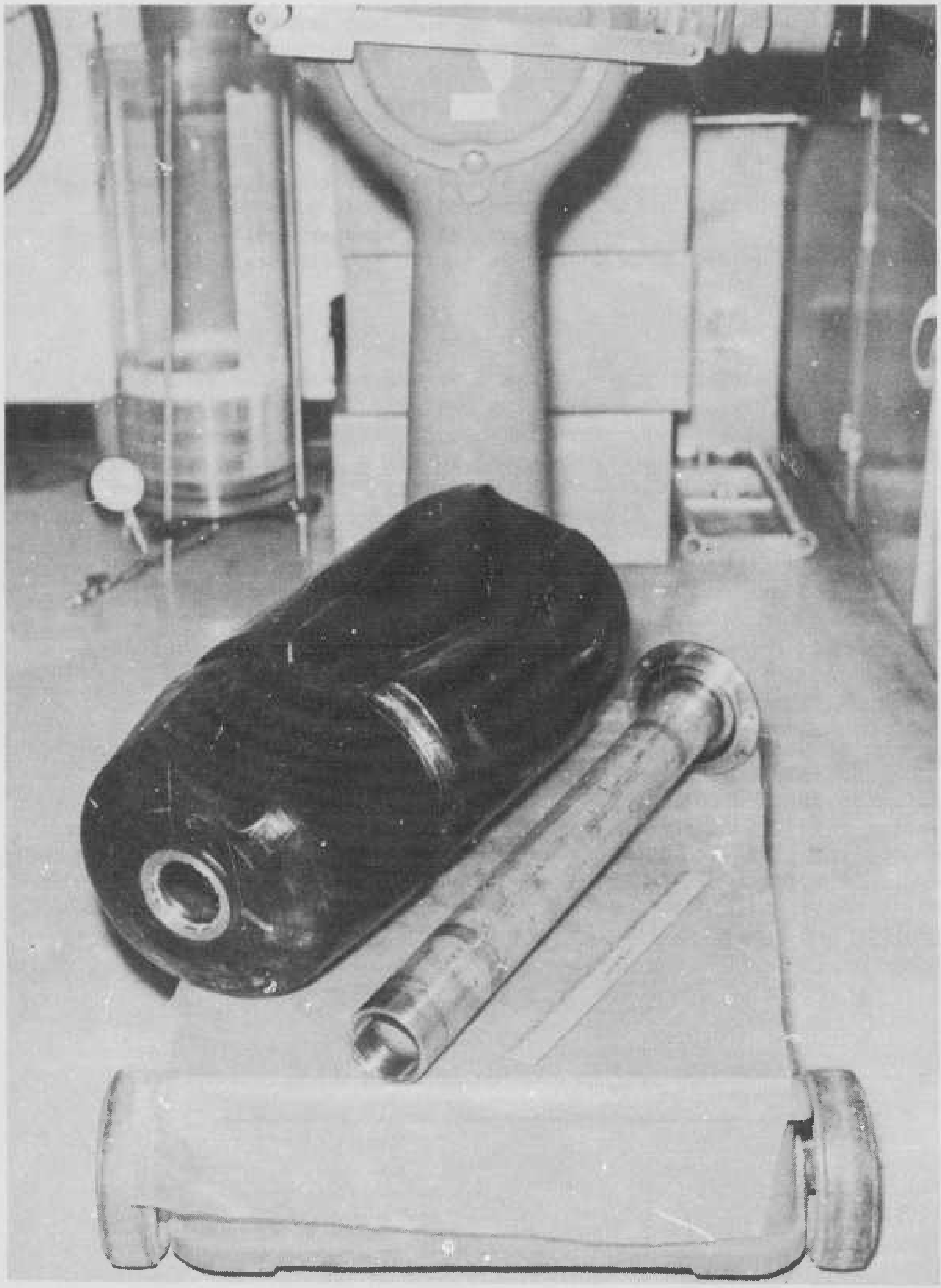


FIG. 3-8. Fuel Collector Pipe.

4
STRUCTURAL ANALYSIS

The structural analysis of the GORJE fuel tank is divided in three parts: (1) the static analysis of the flight test (47.5-pound) tank for inertial loads, flight loads, and internal pressure; (2) a dynamic analysis of the flight test tank to predict the response of the tank to the transient eject load and to predict the factor of safety of the tank when vibration tested as part of the assembled vehicle; and (3) an analysis of the design changes required to result in a flightweight production tank.

This report summarizes the analysis of the flight test tank and that portion of the dynamic analysis pertaining to the response of the tank to the eject load. As part of the structural analysis, extensive calculation was done of air loads and all the possible inertial loads contained in specification MIL-A-8591D were investigated. This report also contains a summary of the load calculations.

The flightweight tank is a design by modification of the flight test tank. The computer models were modified accordingly and the stresses evaluated. Also, the NASTRAN model of the tank used for dynamic analysis was used to determine the response of the tank to the power spectral density curve given in the tank specification.

The configuration of the tank used in the structural analysis models is shown in Fig. B-1 of Appendix B.

STATIC ANALYSIS (FLIGHT TEST TANK)

The computer analyses and the manual calculations show that after the required safety factor has been applied to the loads, all parts of the fuel tank and support lugs have positive margins of safety. A summary of the critical failure modes and the associated margins of safety is given in Table 4-1.

The critical load on the fuel tank is generally the ultimate internal pressure of 550 psi, but both the eject load and a captive flight load, which result in a 16,500-pound ultimate lug load, produce high bending stresses in the strongback adjacent to the shell.

Axial forces in the bottom of the tank shell which might cause buckling have been calculated to be low enough to give high margins of safety for this potential failure mode.

Skin buckling in the vicinity of the strongback because of internal heating by the pressurizing gas is absent because the internal pressure will result in a net tensile stress field in this area.

TABLE 4-1. Summary of Flight Test Model Margins of Safety

Load	Area	Mode	Stress, psi	Allowable Stress, psi	Margin of Safety
P_c = 550 psi	Basic case wall	Hoop	62,500	90,000	0.44
T = 550°F	Forward dome	Plate bending	61,000	90,000	0.47
	Aft dome	Hoop	62,000	90,000	0.45
	Longitudinal weld	Hoop	62,500	83,000	0.32
Lug load = 16,500 lb	Lug pin	Shear	71,700	109,000	0.53
	Lug pin	Bearing	82,500	287,000	2.4
	Longeron	Shear	33,400	95,000	1.7
Ejection load = 15,000 lb	Strongback	Bending	134,000	140,000	0.07
	Shell	Axial stress	30,000	95,000	2.1
	Shell	Hoop bending	157,000	See case subsection	
	Forward ring	Bending	83,000	140,000	0.7
Two forward brace loads = 16,500 lb	Forward ring	Bending	83,000	140,000	0.7
	Cone	Axial stress	73,000	95,000	0.3
	Cylinder	Axial stress	86,000	95,000	0.44
	Cylinder	Hoop	80,000	95,000	0.19
Point 2 loads x 1.5 safety factor	Strongback	Bending	130,000	140,000	0.08
	Shell	Hoop bending	79,000	95,000	0.2
	Shell	Axial	45,000	95,000	1.1
	Forward ring	Bending	70,000	140,000	1.0

One of the principal benefits obtained from the use of the three-dimensional structural analysis program, STAGS, was that the tank shell augments the stiffness of the strength of the strongback, thereby permitting design of a minimum weight structure.

The calculated margins of safety for the support lugs have already been verified by component ultimate loads tests.

DYNAMIC ANALYSIS

The NASTRAN analysis for the dynamic ejection load indicated there was no dynamic amplification of the load over application as a static load. The natural frequencies of the tank are larger than the frequency of the (one-cycle) dynamic load so that the structure is able to follow the load in time. This allowed the stress analysis to be performed by the static shell analysis code (STAGS). The NASTRAN dynamic results for displacement under point of application of the load with corresponding static (NASTRAN) results are:

$$\delta_{140} = -0.0355 \text{ inch (dynamic result)}$$

$$\delta_{140} = -0.0374 \text{ inch (static result).}$$

STATIC ANALYSIS

Loads

A summary of the structural loads as defined in the GORJE statement of work in Appendix A can be seen in Fig. 4-1 and 4-2.

Since these requirements did not specify the end reaction or how the lug and brace loads were to be reacted, the inertial and air loads were evaluated in accordance with MIL-A-8591D. The various load combinations are presented in Table 4-2 and air loads used and methods of calculations are presented in Appendix C. The two points indicated by arrows on Table 4-2 were considered worst case and the two combined load conditions applied to the analysis model.

The material degradation because of the free flight temperature will only affect the pressurized loading condition. The reduced allowable strengths for the material were used for this condition.

Materials

The material used for the structural members was 4130 steel heat treated to various levels in accordance with the drawing requirements. The free flight internal temperature of 550°F will reduce the allowable strength to 95% of room temperature values in accordance with MIL-HNBK-5B. The following room temperature strength levels were used:

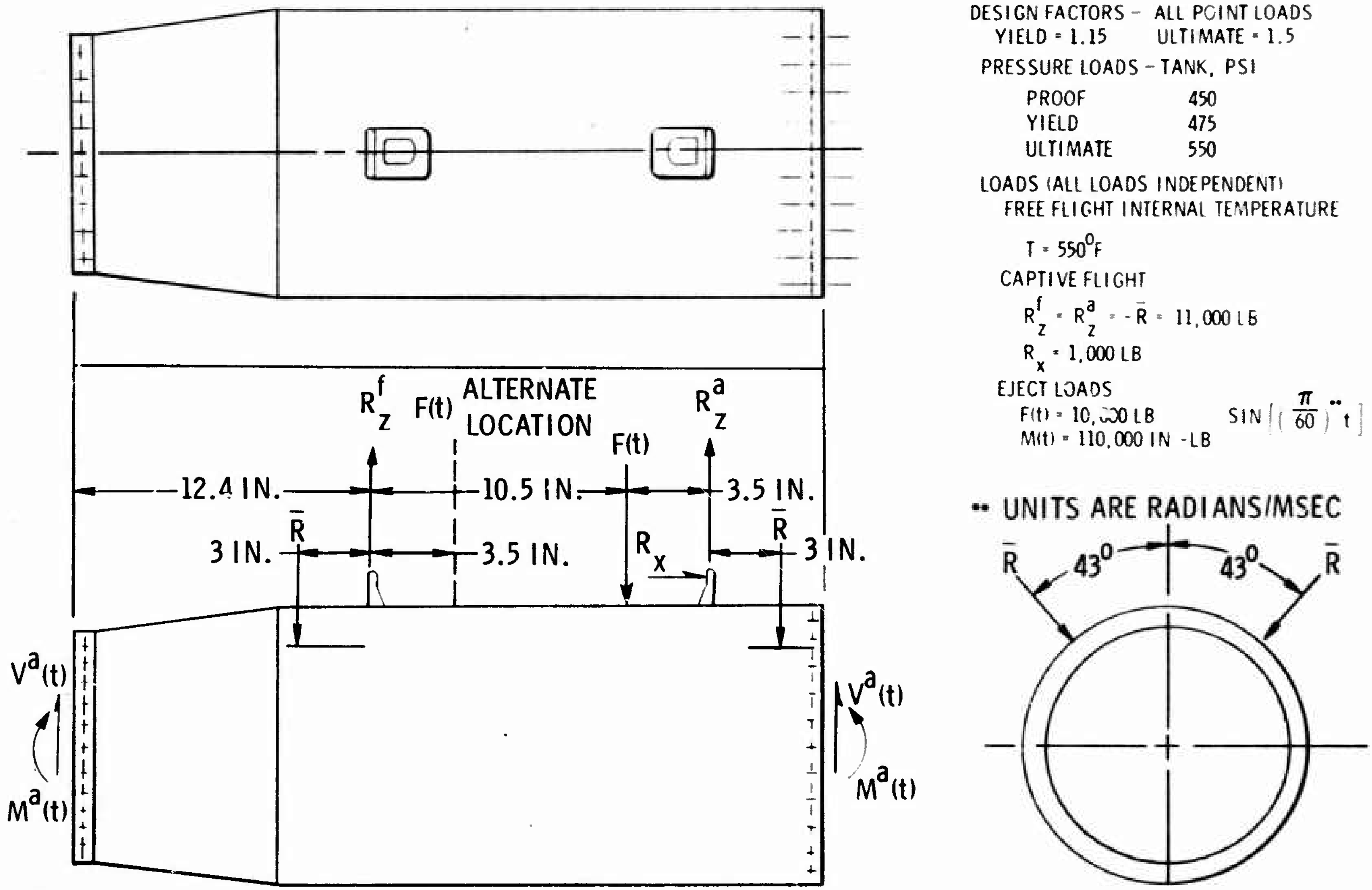
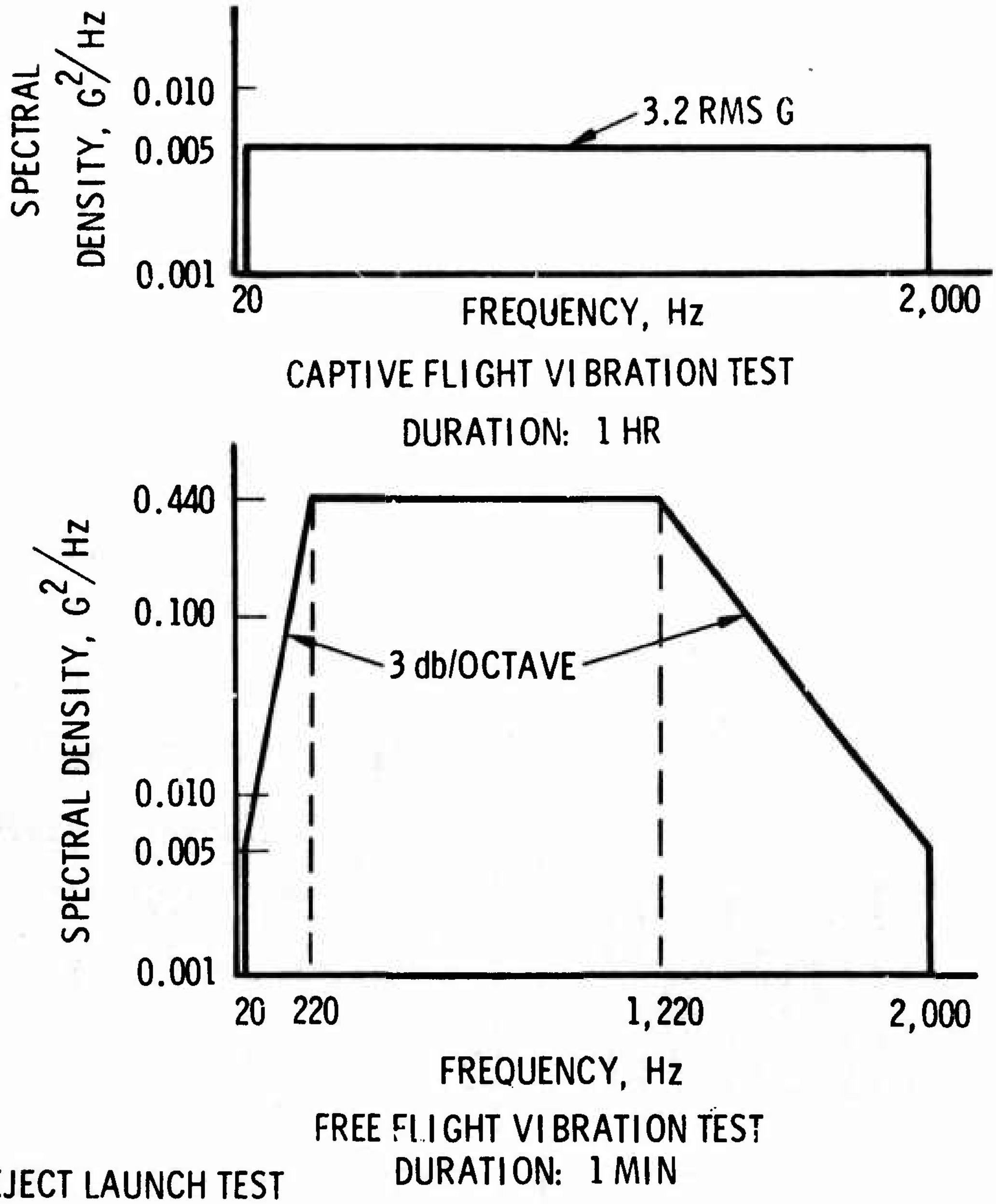


FIG. 4-1. Fuel Management System Structural Criteria.



NOTE: EJECT LAUNCH TEST

PULSE: $F(t) = (10{,}000 \text{ LB}) \text{ SIN}\left[\left(\frac{\pi}{60}\right) t\right]$

t IN MSEC

$0 \leq t \leq 60$ MSEC

FIG. 4-2. Captive Flight and Free Flight Vibration Tests.

TABLE 4-2. GORJE Fuel Tank Loads Analysis.

Column Heading		MIL-A-8591D Nomenclature	Column Heading		MIL-A-8591D Nomenclature
Point	Point	Ref. figure 4-3	VBF	$\bar{V}^{f}_{py,mz}$	Vertical component of forward sway brace
NX	n_x	Longitudinal load factor	VBA	$\bar{V}^{a}_{py,mz}$	Vertical component of aft sway brace
NY	n_y	Lateral load factor	RTF	$R^{f^1}_{z}$	Forward lug reaction
NZ	n_z	Vertical load factor	RTA	$R^{a^1}_{z}$	Aft lug reaction
A	α	Angle of attack	RF	R^{f}_{z}	Forward lug
B	β	Yaw angle of attack	RA	R^{a}_{z}	Aft lug
PX	P_x	Total longitudinal load	RBF	$\bar{R}^{f}$	Forward sway brace
PY	P_y	Total lateral load	RBA	$\bar{R}^{a}$	Aft sway brace
PZ	P_z	Total vertical load			
MY	M_y	Total pitching moment			
MZ	M_z	Total yawing moment			

POINT	NX	NY	NZ	A	B	PX	PY	PZ	MY	MZ	VBF	VBA	RTF	RTA	RF	RA		RBF		RBA
1	1.5	1.5	-11.5	0.0	0.0	1113	1113	-8533	14000	7000	942	251	4609	5118	4609	5118	1289	0	344	0
1	1.5	1.5	-11.5	0.0	0.0	1113	1113	-8533	14000	-7000	192	1002	3536	6190	3536	6190	262	0	1371	0
1	1.5	1.5	-11.5	0.0	0.0	1113	1113	-8533	-14000	7000	942	251	6609	3118	6609	3118	1289	0	344	0
1	1.5	1.5	-11.5	0.0	0.0	1113	1113	-8533	-14000	-7000	192	1002	5536	4190	5536	4190	262	0	1371	0
2	1.5	-1.5	-11.5	0.0	0.0	1113	-1113	-8533	14000	7000	-192	-1002	3536	6190	3536	6190	262	0	1371	0
2	1.5	-1.5	-11.5	0.0	0.0	1113	-1113	-8533	14000	-7000	-942	-251	4609	5118	4609	5118	1289	0	344	0
2	1.5	-1.5	-11.5	0.0	0.0	1113	-1113	-8533	-14000	7000	-192	-1002	5536	4190	5536	4190	262	0	1371	0
2	1.5	-1.5	-11.5	0.0	0.0	1113	-1113	-8533	-14000	-7000	-942	-251	6609	3118	6609	3118	1289	0	344	0
3	1.5	1.5	6.5	0.0	0.0	1113	1113	4823	14000	7000	942	251	-1592	-2037	0	0	2738	1449	1960	1616
3	1.5	1.5	6.5	0.0	0.0	1113	1113	4823	14000	-7000	192	1002	-2665	-965	0	0	2225	1963	2473	1103
3	1.5	1.5	6.5	0.0	0.0	1113	1113	4823	-14000	7000	942	251	408	-4037	0	0	1611	322	3087	2743
3	1.5	1.5	6.5	0.0	0.0	1113	1113	4823	-14000	-7000	192	1002	-665	-2965	0	0	1098	836	3600	2229
4	1.5	-1.5	6.5	0.0	0.0	1113	-1113	4823	14000	7000	-192	-1002	-2665	-965	0	0	1963	2225	1103	2473
4	1.5	-1.5	6.5	0.0	0.0	1113	-1113	4823	14000	-7000	-942	-251	-1592	-2037	0	0	1449	2738	1616	1960
4	1.5	-1.5	6.5	0.0	0.0	1113	-1113	4823	-14000	7000	-192	-1002	-665	-2965	0	0	836	1098	2229	3600
4	1.5	-1.5	6.5	0.0	0.0	1113	-1113	4823	-14000	-7000	-942	-251	408	-4037	0	0	322	1611	2743	3087
5	1.5	-7.5	1.0	0.0	0.0	1113	-5565	742	14000	7000	-2459	-3508	1447	3779	1447	3779	3364	0	4800	0
5	1.5	-7.5	1.0	0.0	0.0	1113	-5565	742	14000	-7000	-3210	-2758	2519	2707	2519	2707	4391	0	3773	0
5	1.5	-7.5	1.0	0.0	0.0	1113	-5565	742	-14000	7000	-2459	-3508	3447	1779	3447	1779	3364	0	4800	0
5	1.5	-7.5	1.0	0.0	0.0	1113	-5565	742	-14000	-7000	-3210	-2758	4519	707	4519	707	4391	0	3773	0
6	1.5	-7.5	-6.0	0.0	0.0	1113	-5565	-4452	14000	7000	-2459	-3508	3858	6562	3858	6562	3364	0	4800	0
6	1.5	-7.5	-6.0	0.0	0.0	1113	-5565	-4452	14000	-7000	-3210	-2758	4930	5489	4930	5489	4391	0	3773	0
6	1.5	-7.5	-6.0	0.0	0.0	1113	-5565	-4452	-14000	7000	-2459	-3508	5858	4562	5858	4562	3364	0	4800	0
6	1.5	-7.5	-6.0	0.0	0.0	1113	-5565	-4452	-14000	-7000	-3210	-2758	6930	3489	6930	3489	4391	0	3773	0
2	1.5	-1.5	-11.5	19.9	1.6	1113	-966	-6710	-39094	2731	-346	-691	6736	1010	6736	1010	473	0	945	0

TABLE 4-2. (Contd.).

POINT	NX	NY	NZ	A	B	PX	PY	PZ	MY	MZ	VBF	VBA	RTF	RTA	HF	HA		HBF		HBA
2	1.5	-1.5	-11.5	19.9	-1.6	1113	-1260	-6710	-67094	11269	-37	-1313	8228	-167	8199	0	51	0	1891	94
2	1.5	-1.5	-11.5	19.9	-1.6	1113	-1260	-6710	-67094	-2731	-788	-563	9301	-1240	9082	0	1078	0	1468	699
4	1.5	-1.5	6.5	-19.8	2.6	1113	-875	3009	66827	63	-442	-496	-5183	3112	0	2197	2920	3525	678	0
2	1.5	-1.5	-11.5	19.9	1.6	1113	-966	-6710	-39094	-11269	-1097	60	7783	84	7783	84	1500	0	82	0
2	1.5	-1.5	-11.5	19.9	1.6	1113	-966	-6710	-67094	2731	-346	-691	8736	-990	8562	0	473	0	1502	558
2	1.5	-1.5	-11.5	19.9	1.6	1113	-966	-6710	-67094	-11269	-1097	60	9783	-1916	9445	0	1500	0	1162	1080
2	1.5	-1.5	-11.5	19.9	-1.6	1113	-1260	-6710	-39094	11269	-37	-1313	6228	1833	6228	1833	51	0	1797	0
2	1.5	-1.5	-11.5	19.9	-1.6	1113	-1260	-6710	-39094	-2731	-788	-563	7301	760	7301	760	1078	0	770	0
4	1.5	-1.5	6.5	-19.8	2.6	1113	-875	3009	66827	-13937	-1193	255	-4220	2658	0	1914	2378	4010	348	0
4	1.5	-1.5	6.5	-19.8	2.6	1113	-875	3009	38827	63	-442	-496	-3183	1112	0	550	1793	2398	678	0
4	1.5	-1.5	6.5	-19.8	2.6	1113	-875	3009	38827	-13937	-1193	255	-2220	658	0	267	1251	2883	348	0
4	1.5	-1.5	6.5	-19.8	-2.6	1113	-1351	3009	66827	13937	59	-1508	-5866	4423	0	3388	3385	3305	2063	0
4	1.5	-1.5	6.5	-19.8	-2.6	1113	-1351	3009	66827	-63	-692	-757	-4937	3376	0	2505	2781	3727	1036	0
4	1.5	-1.5	6.5	-19.8	-2.6	1113	-1351	3009	38827	13937	59	-1508	-3866	2423	0	1741	2259	2178	2063	0
4	1.5	-1.5	6.5	-19.8	-2.6	1113	-1351	3009	38827	-63	-692	-757	-2937	1376	0	858	1654	2601	1036	0
5	1.5	-7.5	1.0	-16.2	11.8	1113	-4484	-737	57089	-24483	-3597	-1212	929	4617	929	4617	4921	0	1658	0
5	1.5	-7.5	1.0	-16.2	11.8	1113	-4484	-737	57089	-38483	-4348	-461	2001	3545	2001	3545	5947	0	631	0
5	1.5	-7.5	1.0	-16.2	11.8	1113	-4484	-737	29089	-24483	-3597	-1212	2929	2617	2929	2617	4921	0	1658	0
5	1.5	-7.5	1.0	-16.2	11.8	1113	-4484	-737	29089	-38483	-4348	-461	4001	1545	4001	1545	5947	0	631	0
5	1.5	-7.5	1.0	-16.2	-11.8	1113	-6646	-737	57089	38483	-1322	-5805	-2818	10682	0	10185	1588	3396	7941	0
5	1.5	-7.5	1.0	-16.2	-11.8	1113	-6646	-737	57089	24483	-2073	-5054	-1745	9610	0	9302	984	3819	6914	0
5	1.5	-7.5	1.0	-16.2	-11.8	1113	-6646	-737	29089	38483	-1322	-5805	-818	8682	0	6538	461	2269	7941	0
5	1.5	-7.5	1.0	-16.2	-11.8	1113	-6646	-737	29089	24483	-2073	-5054	255	7610	255	7610	2835	0	6914	0
6	1.5	-7.5	-6.0	18.7	7.2	1113	-4905	-2743	-35786	-12210	-3153	-2107	7764	240	7764	240	4314	0	2883	0
6	1.5	-7.5	-6.0	18.7	7.2	1113	-4905	-2743	-35786	-26210	-3904	-1356	8836	-833	8689	0	5341	0	2325	469
6	1.5	-7.5	-6.0	18.7	7.2	1113	-4905	-2743	-63786	-12210	-3153	-2107	9764	-1760	9453	0	4314	0	3875	992
6	1.5	-7.5	-6.0	18.7	7.2	1113	-4905	-2743	-63786	-26210	-3904	-1356	10836	-2833	10336	0	5341	0	3452	1596
6	1.5	-7.5	-6.0	18.7	-7.2	1113	-6225	-2743	-35786	26210	-1765	-4910	5478	3940	5478	3940	2415	0	6717	0
6	1.5	-7.5	-6.0	18.7	-7.2	1113	-6225	-2743	-35786	12210	-2516	-4159	6550	2868	6550	2868	3442	0	5690	0
6	1.5	-7.5	-6.0	18.7	-7.2	1113	-6225	-2743	-63786	26210	-1765	-4910	7478	1940	7478	1940	2415	0	6717	0
6	1.5	-7.5	-6.0	18.7	-7.2	1113	-6225	-2743	-63786	12210	-2516	-4159	8550	868	8550	868	3442	0	5690	0
1	-1.5	1.5	-11.5	0.0	0.0	-1113	1113	-8533	14000	7000	942	251	3496	6231	3496	6231	1289	0	344	0
1	-1.5	1.5	-11.5	0.0	0.0	-1113	1113	-8533	14000	-7000	192	1002	2423	7303	2423	7303	262	0	1371	0
1	-1.5	1.5	-11.5	0.0	0.0	-1113	1113	-8533	-14000	7000	942	251	5496	4231	5496	4231	1289	0	344	0
1	-1.5	1.5	-11.5	0.0	0.0	-1113	1113	-8533	-14000	-7000	192	1002	4423	5303	4423	5303	262	0	1371	0
2	-1.5	-1.5	-11.5	0.0	0.0	-1113	-1113	-8533	14000	7000	-192	-1002	2423	7303	2423	7303	262	0	1371	0
2	-1.5	-1.5	-11.5	0.0	0.0	-1113	-1113	-8533	14000	-7000	-942	-251	3496	6231	3496	6231	1289	0	344	0
2	-1.5	-1.5	-11.5	0.0	0.0	-1113	-1113	-8533	-14000	7000	-192	-1002	4423	5303	4423	5303	262	0	1371	0
2	-1.5	-1.5	-11.5	0.0	0.0	-1113	-1113	-8533	-14000	-7000	-942	-251	5496	4231	5496	4231	1289	0	344	0
3	-1.5	1.5	6.5	0.0	0.0	-1113	1113	4823	14000	7000	942	251	-2705	-924	0	0	3365	2076	1333	989
3	-1.5	1.5	6.5	0.0	0.0	-1113	1113	4823	14000	-7000	192	1002	-3778	148	0	-518	2390	2128	1371	0
3	-1.5	1.5	6.5	0.0	0.0	-1113	1113	4823	-14000	7000	942	251	-705	-2924	0	0	2238	949	2460	2116
3	-1.5	1.5	6.5	0.0	0.0	-1113	1113	4823	-14000	-7000	192	1002	-1778	-1852	0	0	1725	1463	2973	1602
4	-1.5	-1.5	6.5	0.0	0.0	-1113	-1113	4823	14000	7000	-192	-1002	-3778	148	0	-518	2128	2390	1371	0
4	-1.5	-1.5	6.5	0.0	0.0	-1113	-1113	4823	14000	-7000	-942	-251	-2705	-924	0	0	2076	3365	989	1333
4	-1.5	-1.5	6.5	0.0	0.0	-1113	-1113	4823	-14000	7000	-192	-1002	-1778	-1852	0	0	1463	1725	1602	2973
4	-1.5	-1.5	6.5	0.0	0.0	-1113	-1113	4823	-14000	-7000	-942	-251	-705	-2924	0	0	949	2238	2116	2460
5	-1.5	-7.5	1.0	0.0	0.0	-1113	-5565	742	14000	7000	-2459	-3508	334	4892	334	4892	3364	0	4800	0
5	-1.5	-7.5	1.0	0.0	0.0	-1113	-5565	742	14000	-7000	-3210	-2758	1406	3820	1406	3820	4391	0	3773	0
5	-1.5	-7.5	1.0	0.0	0.0	-1113	-5565	742	-14000	7000	-2459	-3508	2334	2892	2334	2892	3364	0	4800	0

TABLE 4-2. (Contd.).

POINT		NX	NY	NZ	A	B	PX	PY	PZ	MY	MZ	VBF	VBA	RTF	RTA	RF	RA	RBF		KBA
5	-1.5	-7.5	1.0	0.0	0.0	-1113	-5565	742	-14000	-7000	-3210	-2758	3406	1820	3406	1820	4391	0	3773	0
6	-1.5	-7.5	-6.0	0.0	0.0	-1113	-5565	-4452	14000	7000	-2459	-3508	2745	7675	2745	7675	3364	0	4800	0
6	-1.5	-7.5	-6.0	0.0	0.0	-1113	-5565	-4452	14000	-7000	-3210	-2758	3817	6602	3817	6602	4391	0	3773	0
6	-1.5	-7.5	-6.0	0.0	0.0	-1113	-5565	-4452	-14000	7000	-2459	-3508	4745	5675	4745	5675	3364	0	4800	0
6	-1.5	-7.5	-6.0	0.0	0.0	-1113	-5565	-4452	-14000	-7000	-3210	-2758	5817	4602	5817	4602	4391	0	3773	0
2	-1.5	-1.5	-11.5	19.9	1.6	-1113	-966	-6710	-39094	2731	-346	-691	5623	2123	5623	2123	473	0	945	0
2	-1.5	-1.5	-11.5	19.9	1.6	-1113	-966	-6710	-39094	-11269	-1097	60	6670	1197	6670	1197	1500	0	82	0
2	-1.5	-1.5	-11.5	19.9	1.6	-1113	-966	-6710	-67094	2731	-346	-691	7623	123	7623	123	473	0	945	0
2	-1.5	-1.5	-11.5	19.9	1.6	-1113	-966	-6710	-67094	-11269	-1097	60	8670	-803	8528	0	1500	0	535	453
2	-1.5	-1.5	-11.5	19.9	-1.6	-1113	-1260	-6710	-39094	11269	-37	-1313	5115	2946	5115	2946	51	0	1797	0
2	-1.5	-1.5	-11.5	19.9	-1.6	-1113	-1260	-6710	-39094	-2731	-788	-563	6188	1873	6188	1873	1078	0	770	0
2	-1.5	-1.5	-11.5	19.9	-1.6	-1113	-1260	-6710	-67094	11269	-37	-1313	7115	946	7115	946	51	0	1797	0
2	-1.5	-1.5	-11.5	19.9	-1.6	-1113	-1260	-6710	-67094	-2731	-788	-563	8188	-127	8165	0	1078	0	841	72
4	-1.5	-1.5	6.5	-19.8	2.6	-1113	-875	3009	66827	63	-442	-496	-6296	4225	0	3114	3547	4152	678	0
4	-1.5	-1.5	6.5	-19.8	2.6	-1113	-875	3009	66827	-13937	-1193	255	-5333	3771	0	2830	3005	4637	348	0
4	-1.5	-1.5	6.5	-19.8	2.6	-1113	-875	3009	38827	63	-442	-496	-4296	2225	0	1467	2421	3026	678	0
4	-1.5	-1.5	6.5	-19.8	2.6	-1113	-875	3009	38827	-13937	-1193	255	-3333	1771	0	1183	1878	3510	348	0
4	-1.5	-1.5	6.5	-19.8	-2.6	-1113	-1351	3009	66827	13937	59	-1508	-6979	5536	0	4305	4012	3932	2063	0
4	-1.5	-1.5	6.5	-19.8	-2.6	-1113	-1351	3009	66827	-63	-692	-757	-6050	4489	0	3422	3408	4354	1036	0
4	-1.5	-1.5	6.5	-19.8	-2.6	-1113	-1351	3009	38827	13937	59	-1508	-4979	3536	0	2658	2886	2805	2063	0
4	-1.5	-1.5	6.5	-19.8	-2.6	-1113	-1351	3009	38827	-63	-692	-757	-4050	2489	0	1775	2281	3228	1036	0
5	-1.5	-7.5	1.0	-16.2	11.8	-1113	-4484	-737	57089	-24483	-3597	-1212	-184	5730	0	5698	104	5025	1658	0
5	-1.5	-7.5	1.0	-16.2	11.8	-1113	-4484	-737	57089	-38483	-4348	-461	888	4658	888	4658	5947	0	631	0
5	-1.5	-7.5	1.0	-16.2	11.8	-1113	-4484	-737	29089	-24483	-3597	-1212	1816	3730	1816	3730	4921	0	1658	0
5	-1.5	-7.5	1.0	-16.2	11.8	-1113	-4484	-737	29089	-38483	-4348	-461	2888	2658	2388	2658	5947	0	631	0
5	-1.5	-7.5	1.0	-16.2	-11.8	-1113	-6646	-737	57089	38483	-1322	-5805	-3931	11795	0	11101	2215	4023	7941	0
5	-1.5	-7.5	1.0	-16.2	-11.8	-1113	-6646	-737	57089	24483	-2073	-5054	-2858	10723	0	10218	1611	4446	6914	0
5	-1.5	-7.5	1.0	-16.2	-11.8	-1113	-6646	-737	29089	38483	-1322	-5805	-1931	9795	0	9454	1088	2896	7941	0
5	-1.5	-7.5	1.0	-16.2	-11.8	-1113	-6646	-737	29089	24483	-2073	-5054	-858	8723	0	8571	484	3319	6914	0
6	-1.5	-7.5	-6.0	18.7	7.2	-1113	-4905	-2743	-35786	-12210	-3153	-2107	6651	1353	6651	1353	4314	0	2883	0
6	-1.5	-7.5	-6.0	18.7	7.2	-1113	-4905	-2743	-35786	-26210	-3904	-1356	7723	280	7723	280	5341	0	1856	0
6	-1.5	-7.5	-6.0	18.7	7.2	-1113	-4905	-2743	-63786	-12210	-3153	-2107	8651	-647	8536	0	4314	0	3247	365
6	-1.5	-7.5	-6.0	18.7	7.2	-1113	-4905	-2743	-63786	-26210	-3904	-1356	9723	-1720	9420	0	5341	0	2825	969
6	-1.5	-7.5	-6.0	18.7	-7.2	-1113	-6225	-2743	-35786	26210	-1765	-4910	4365	5053	4365	5053	2415	0	6717	0
6	-1.5	-7.5	-6.0	18.7	-7.2	-1113	-6225	-2743	-35786	12210	-2516	-4159	5437	3981	5437	3981	3442	0	5690	0
6	-1.5	-7.5	-6.0	18.7	-7.2	-1113	-6225	-2743	-63786	26210	-1765	-4910	6365	3053	6365	3053	2415	0	6717	0
6	-1.5	-7.5	-6.0	18.7	-7.2	-1113	-6225	-2743	-63786	12210	-2516	-4159	7437	1981	7437	1981	3442	0	5690	0

Part	Drawing Number	F_{tu}, psi x 10^3	F_{ty}, psi x 10^3	F_{su}, psi x 10^3	F_{tu} at 550°F, psi x 10^3
Lug	C11207	180	163	108	171
Longeron	C11204	150	132	90	142
Forward closure	C11202	95	75	57	90
Tank shell	C11206	95	75	57	90
Aft closure	C11201	150	132	90	142
Ring	C11203	150	132	90	142
Cone	C11027	95	75	57	90

Method of Analysis and Results

The production model was checked for: (1) internal pressure of 550 psi; (2) ejection load of 10,000 pounds in either location; (3) both forward brace loads being 11,000 pounds; and (4) Point 2 captive flight inertia and air load from Table 4-2.

These are the worst case loading conditions and the margins from these runs are large enough so that the other load conditions need only be checked on the flight model. For a summary of the safety margins see Table 4-1.

The STAGS analysis used two models, a 180-degree model for symmetric loads and a 360-degree model for the nonsymmetric Point 2 loading. The models are otherwise identical. The axial profile is shown in Fig. 4-3 and a typical cross section is shown in Figs. 4-4 and 4-5.

Three preliminary sizing and model checkout runs were made which varied the model density, method of modeling the strongback and shell buildup, and strongback inertia. These runs substantiated the model's adequacy. The results of these preliminary runs are on file but have not been presented because they are not directly comparable and there is no substantial difference from the final results which are presented here (e.g., maximum strongback radial deflection under ejection load of 0.083, 0.074, and 0.087 inch as compared to a final design value of 0.084 inch).

Closure and Case Pressurized. The end closures were analyzed using the CSD finite element computer program LI65ZZZ. The model, boundary condition, and results are shown in Figs. 4-6 and 4-7. The loading used was the ultimate internal pressure of 550 psi. The closure stress for the captive flight loading conditions was verified by the STAGS analysis to be appreciably less.

The aft closure-to-collector pipe flange joint was analyzed using the LI65ZZZ finite element program. The finite element model is presented in Fig. 4-8. Both the hydrotest and the flight loading conditions were used. The hydrotest condition provided the most severe loading condition. The interface on the model between the two flanges contained a thin row of

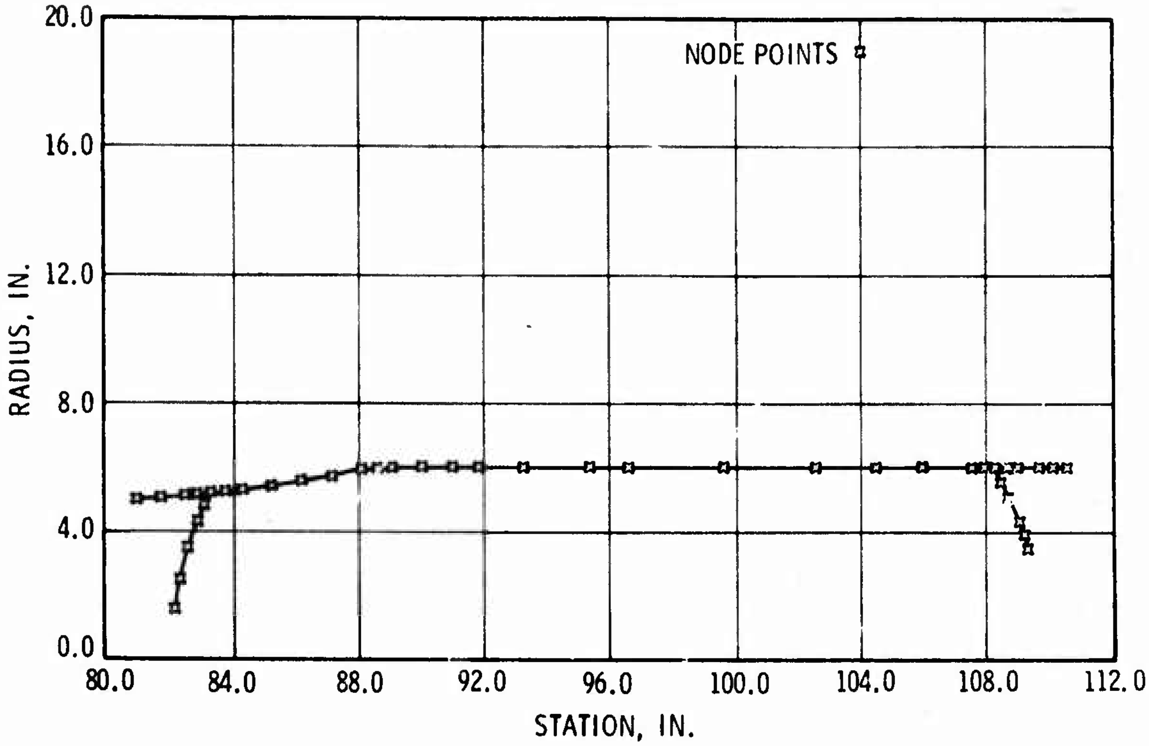


FIG. 4-3. STAGS Model.

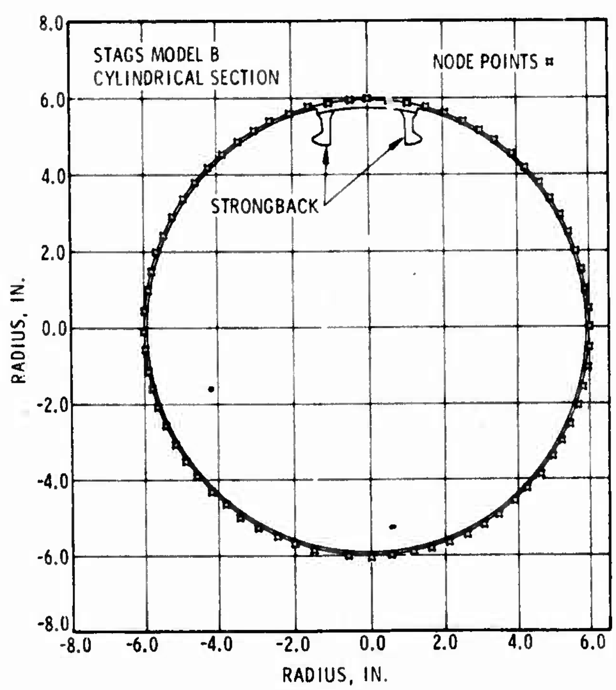


FIG. 4-4. STAGS Model B Cylindrical Section.

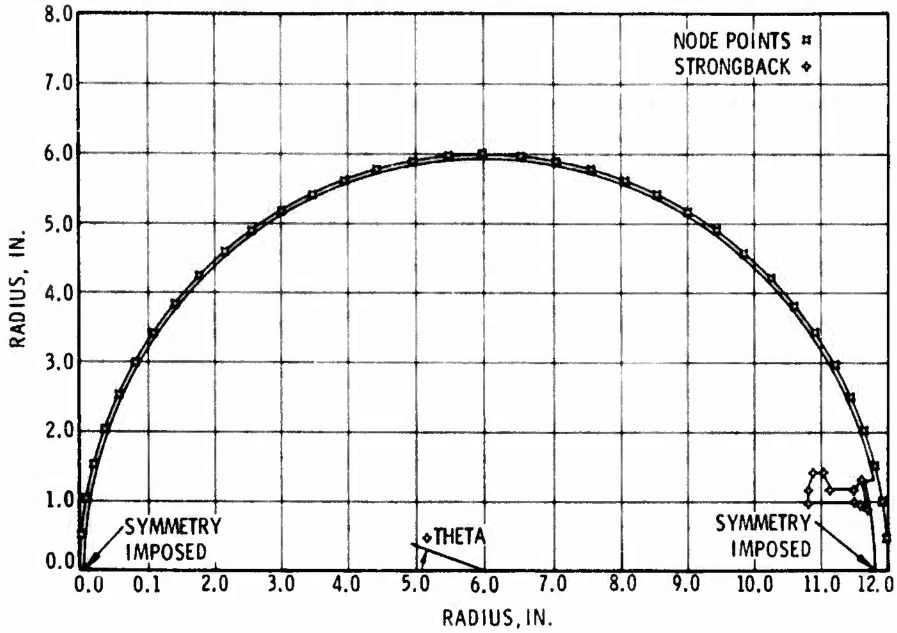


FIG. 4-5. STAGS Model A Cylindrical Section.

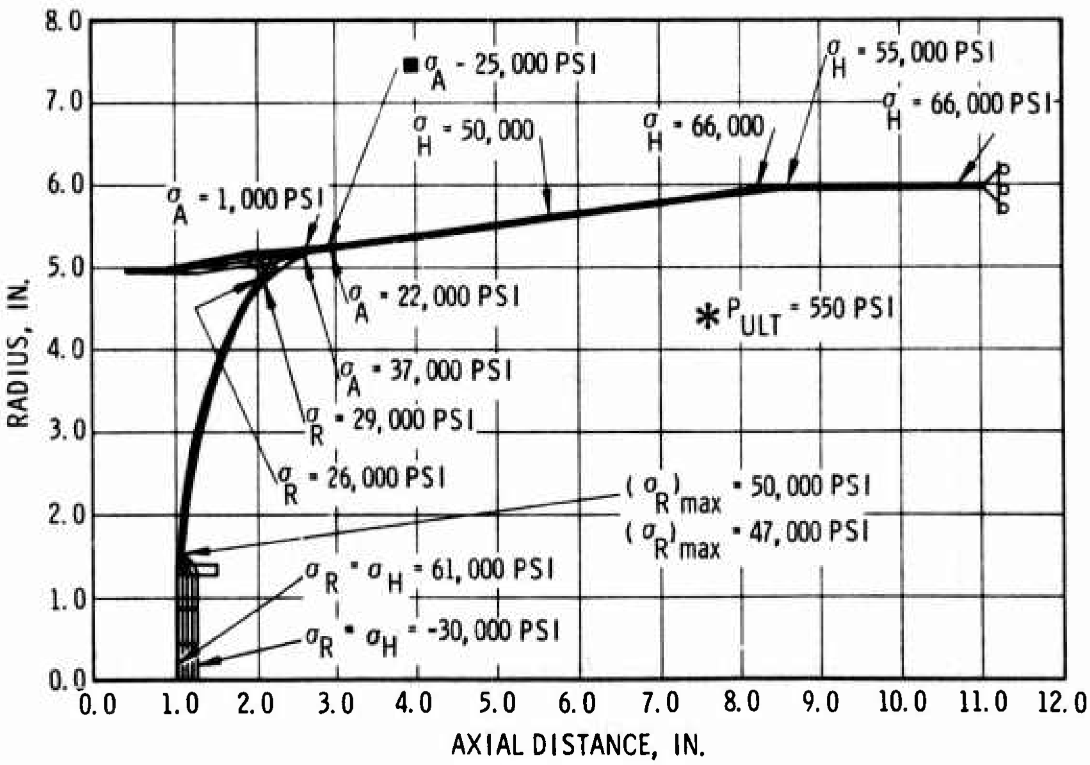


FIG. 4-6. Forward Closure.

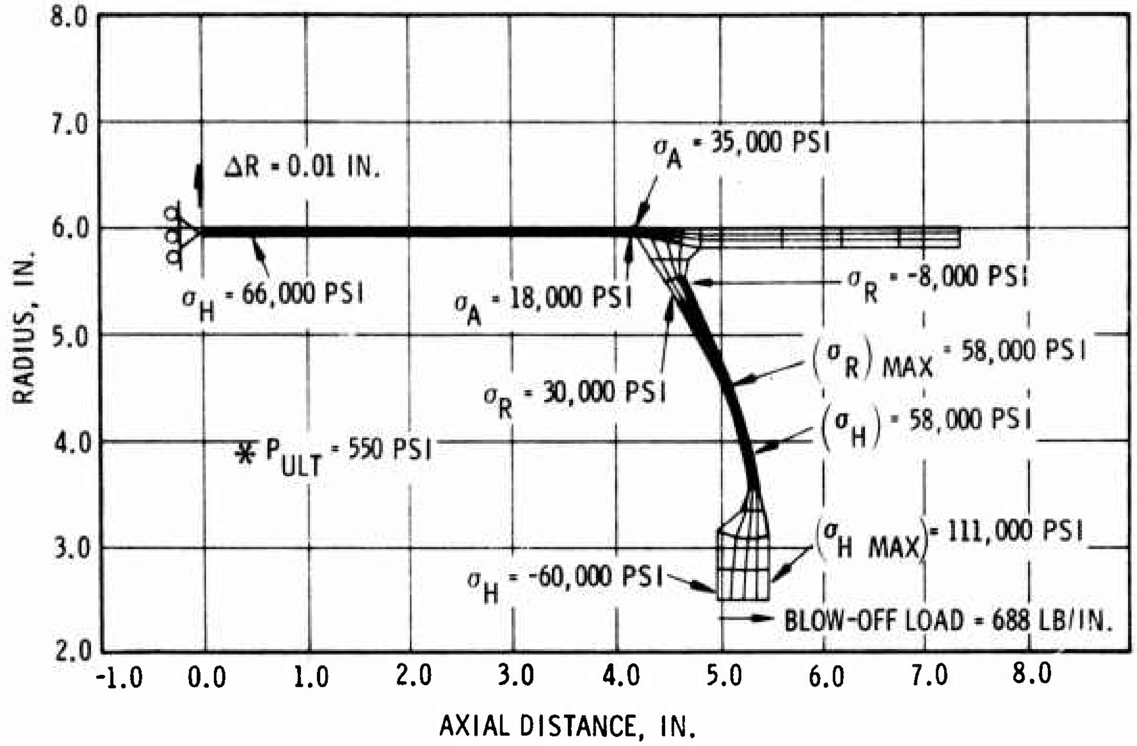


FIG. 4-7. Aft Closure.

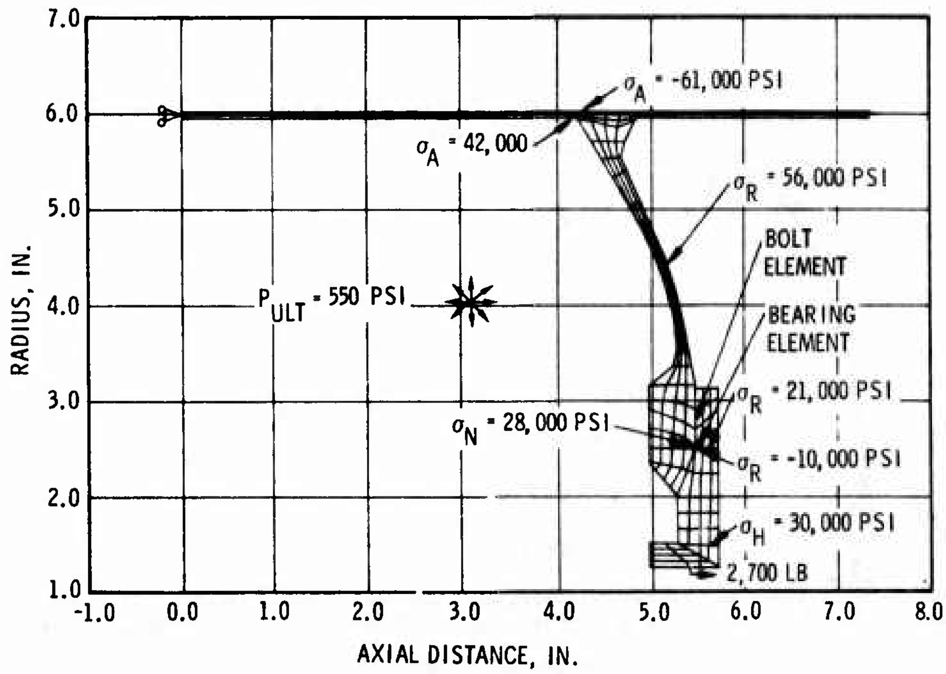


FIG. 4-8. Aft Closure.

elements. The bolt element was given a modulus which gives it the same spring rate as the bolts. The bearing element was hydrostatic to eliminate any shear restraint. The other interface elements were given a very low modulus (10). Although an early run used a bearing element at the outside diameter of the flange, the results were tension in the bearing element and compression in the bolt element. Thus, the model was changed to a bearing element at the inside diameter of the flange. The aft closure flange tended to rotate and the collector pipe flange restrained the rotation of the closure, resulting in a bolt load which was three times the blowout load.

Main Ring. The main ring was preliminary-sized using NASA TN 929* for a circular shell supported frame. The uncertainty in this method is estimating the relative stiffness (term d) of the shell. A best guess for d of 500 gave a ring stress of 54,000 psi because of an 11,000-pound brace load. However, a d of 10 would give a stress of 120,000 psi. A STAGS run was made applying a forward brace load of 11,000 pounds. Because of symmetry specified at the boundary of 0 and 180 degrees, these results are for worst case loading of both forward brace loads, or 11,000 pounds. The ring deflection and stress are shown in Figs. 4-9 and 4-10. The maximum stress in the ring as a result of the ejection load was also 54,000 psi, as shown by Fig. 4-11.

* Analysis of Circular Shell Supported Frames, NASA Technical Note No. 929, May 1944.

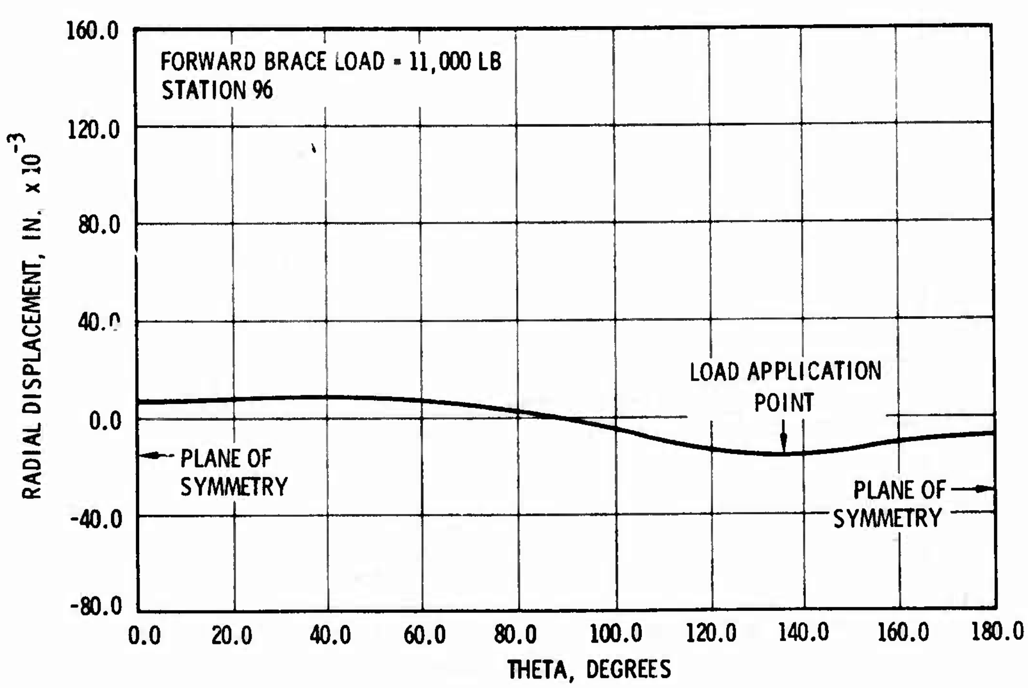


FIG. 4-9. Ring Displacement.

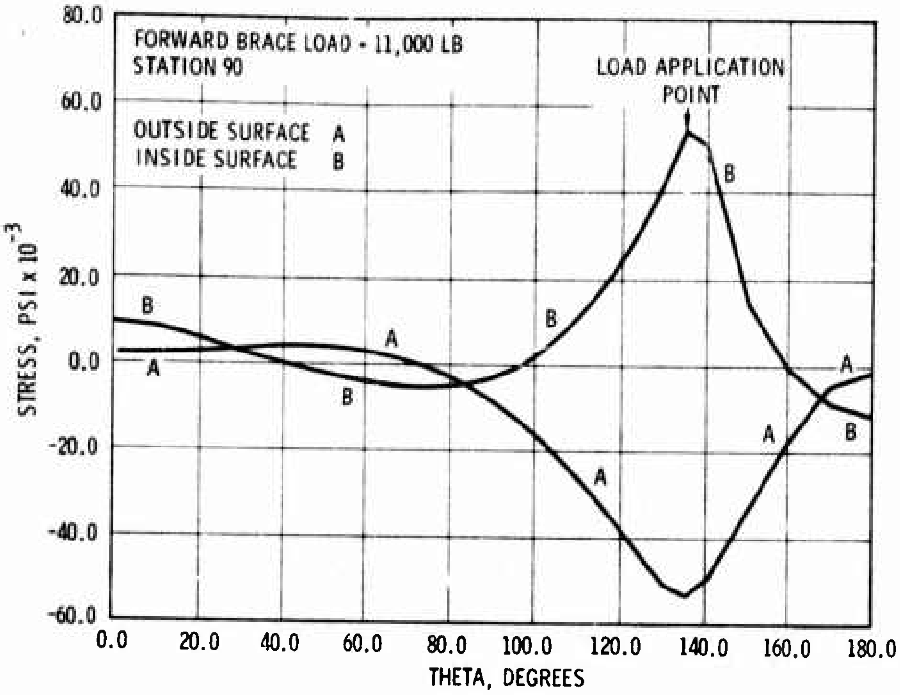


FIG. 4-10. Ring Stress.

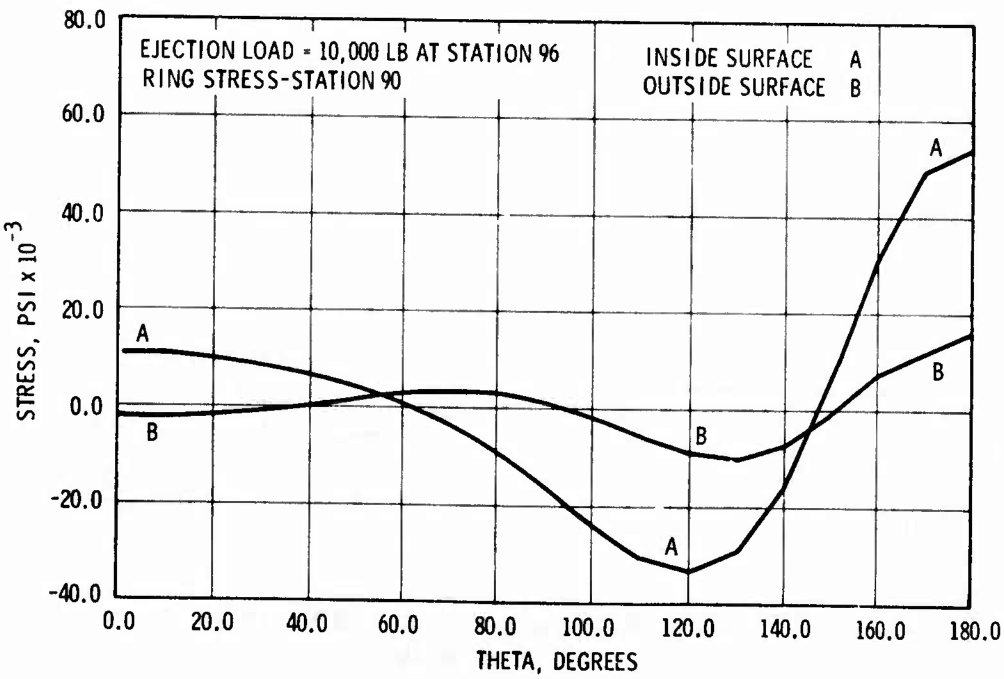


FIG. 4-11. Ring Stress Station 90.

Longeron. The longeron was checked by STAGS analysis for the ejection load in its allowable location and the forward lug load.

Preliminary manual calculations for a simple beam showed the worst case loading for moment in the longeron to be an ejection load of 10,000 pounds at Station 96. The STAGS results have shown that the support provided by the skin makes the stress and deflection relatively independent of the load location. A comparison of longeron radial deformation for the ejection load at Stations 96 and 103 is shown in Fig. 4-12. The stress and deformation patterns for the loading at Station 103 are similar and only slightly less than those for loading at Station 96.

Since completion of the analysis, the Station 96 location has been dropped and the ejection load will only be applied at Station 103. The tables of safety reflect the values for Station 103.

The maximum stress for the ejection load of 10,000 pounds was 90,000 psi. The Point 2 flight loading gave a maximum longeron stress of 87,000 psi. These are all elastic stresses at the surface; plastic capabilities would provide greater margins.

Case. For the captive flight load, the membrane stress levels in the basic shell wall are all very low (i.e., 25,000 psi or less). There is no problem with the ultimate safety factor. However, there are small localized areas with high bending stress which cannot theoretically meet the required safety factor upon yield. Under the ejection load, at the junction of the shell to the strongback, the STAGS program predicts a large moment in the shell because the strongback does not rotate. Compatibility of rotation causes a high bending stress in the shell as shown by Fig. 4-13. Examination of the displacements, as shown in Fig. 4-14, indicates there is no great discontinuity in replacements. Minor plastic redistribution would allow rotation at the juncture, thus removing the moment. This is not a moment that must be carried by the shell but one that results because of the compatibility of rotation requirement that has been imposed by the computer program.

The lug loading was in the opposite direction and the maximum stress was only 53,000 psi at the juncture for the Point 2 loading condition.

These stress levels are not realistic for design of the structure and have been presented only for completeness of the report.

The critical load on the attachment flanges is the requirement of a moment of 110,000 in-lb that results from the ejection load. The captive flight loads give smaller end moments. A moment of 165,000 in-lb ultimate distributed as a cosine variation results in a maximum axial line load of 1,460 pounds/inch ultimate. This gives a maximum bolt load of 1,955 pounds and shell stress of 29,000 psi. Conformation has been made with the STAGS analysis, which applied end moments of 72,000 in-lb and there were no unexpected stresses.

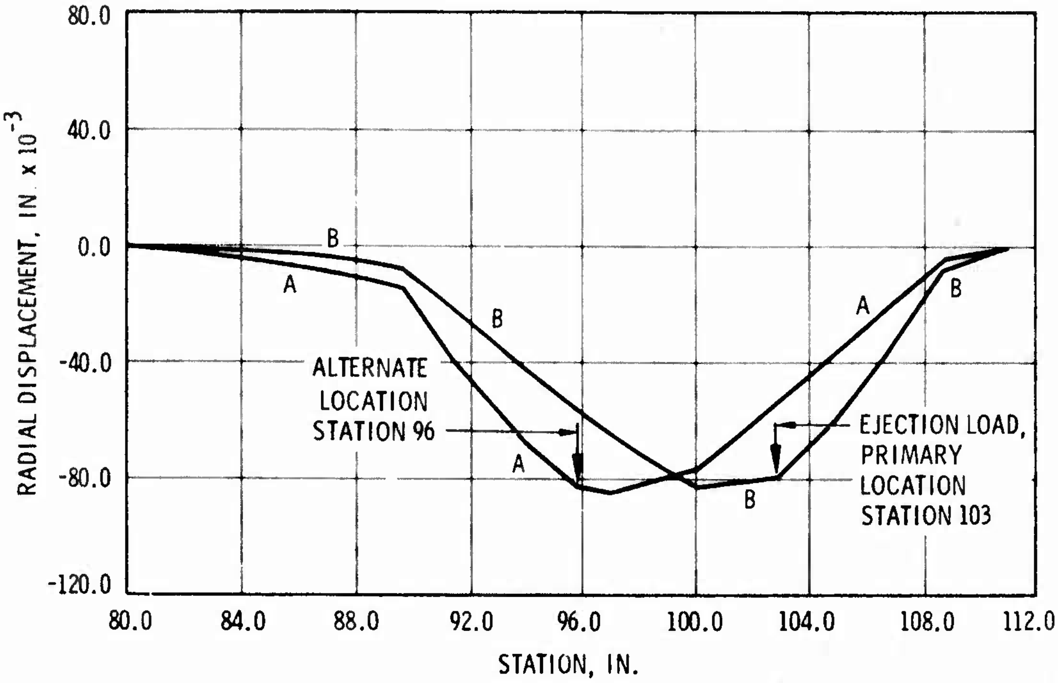


FIG. 4-12. Strongback Radial Displacement.

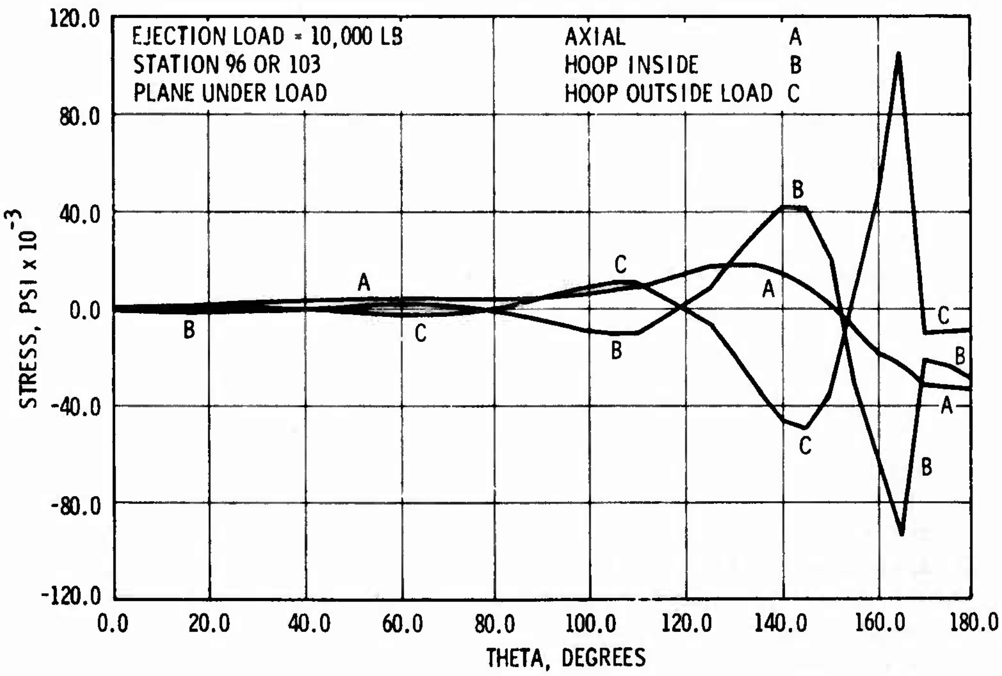


FIG. 4-13. Plane Under Load.

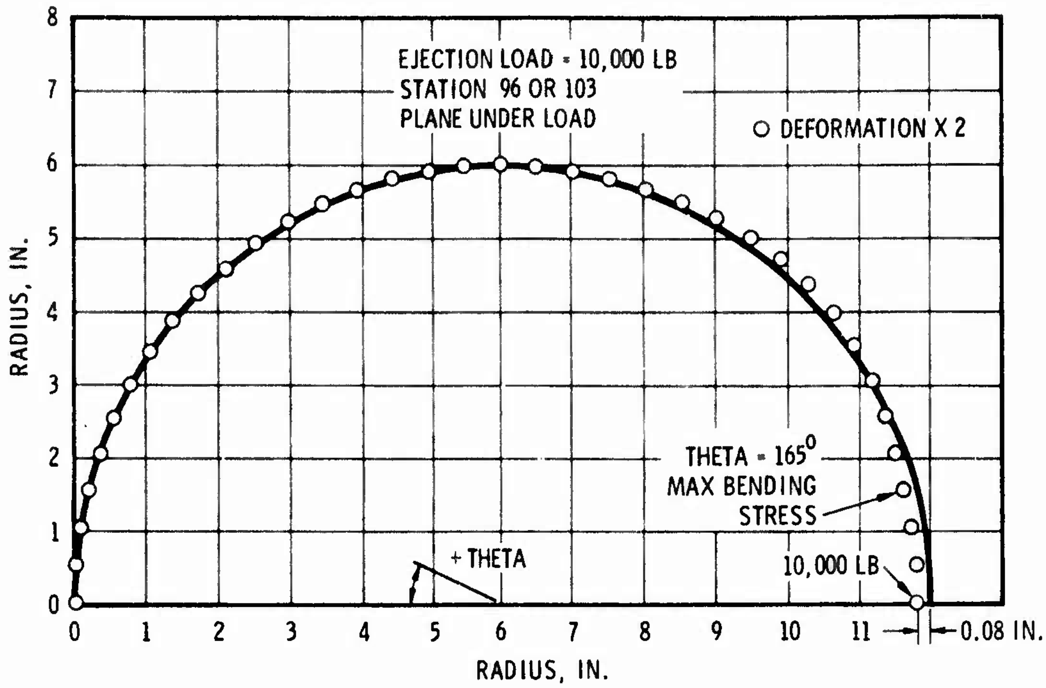


FIG. 4-14. Plane Under Load.

Lugs

The lugs were analyzed by manual calculation and the critical margin was a 0.5 margin on pin shear. A lug and retention system model has since been tested to an ultimate loading of 16,500 pounds with no visible yielding.

DYNAMIC ANALYSIS

NASTRAN Dynamic Model

A NASTRAN model of the GORJE tank was constructed mainly to study the natural modes of vibration and dynamic response of the tank. The problem was run on a CDC 6600 using a MacNeal Schwendler version of NASTRAN (MSC-20). As the tank is symmetrical about a vertical plane through the center, the cyclic symmetry option was used.

The various model elements are described as follows:

1. The end sections of the tank were modeled with rectangular and triangular plate sections.
2. The longitudinal sections of the tank were modeled with rectangular plates.
3. The fluid was modeled by use of solids having a high bulk modulus (simulating incompressibility).
4. The longitudinal stiffeners (longeron) and the forward ring were modeled with offset beams. These beams are not shown in the computer drawings.

A number of NASTRAN drawings of various sections of the structural model were drawn primarily to check for errors in the model. However, these drawings provide a vivid picture of the structural model of the (half) tank. Figs. 4-15 through 4-17 show the front, side, and rear elevations, respectively, of the outer shell of the tank. Figs. 4-18 through 4-25 show the sections comprised of solid elements used to model the fluid of the half-filled tank. These sections are shown as orthographic views. In some studies, these fluid sections were omitted from the model. A listing of the NASTRAN bulk data (Table 4-3) identifies the elements and the nodal points of the drawings and the structural model.

This model was used for two types of studies: (1) dynamic response of the tank to an ejection load and (2) frequency-modal analysis of the tank structure. In both of these studies, the fluid elements were removed from the tank so that the results pertain to an empty tank. The inertial effect of the missile sections forward and aft of the tank was incorporated into this model.

Dynamic Analysis of the Ejection Load

The NASTRAN model was primarily used to study dynamic loads. The direct integration method (APP DISP 9) was used to study the response to the dynamic ejection load. This load is characterized in the specifications:

$$F(t) = (10{,}000 \text{ lb})/\sin(\pi t/60)/ \qquad 0 \leq t \leq 60$$
$$F(t) = 0 \qquad t > 60$$

where the time (t) is in msec.

With reference to Fig. 4-16 of the structural model, the ejection load was applied as a vertical load on point 140 of the model. The tank was supported on very soft springs at two points (5 and 185) in the vertical direction only.

The radial displacement of the shell centerline is given under point of application of the load. The maximum value shown on this plot is slightly less than that obtained from a shell static analysis.

It should be noted that the displacements and stress distribution followed the applied load in form. As could be shown by a frequency-modal analysis of the tank, the frequencies are in such a range that excitation of the tank would not be expected.

In Fig. 4-26, the radial displacement of the point under the load is plotted versus time. In Fig. 4-27, a plot of the maximum (and minimum) stress in the beam reinforcement (strongback) section of the tank is plotted versus time. These stresses occur in extreme fibers of the beams.

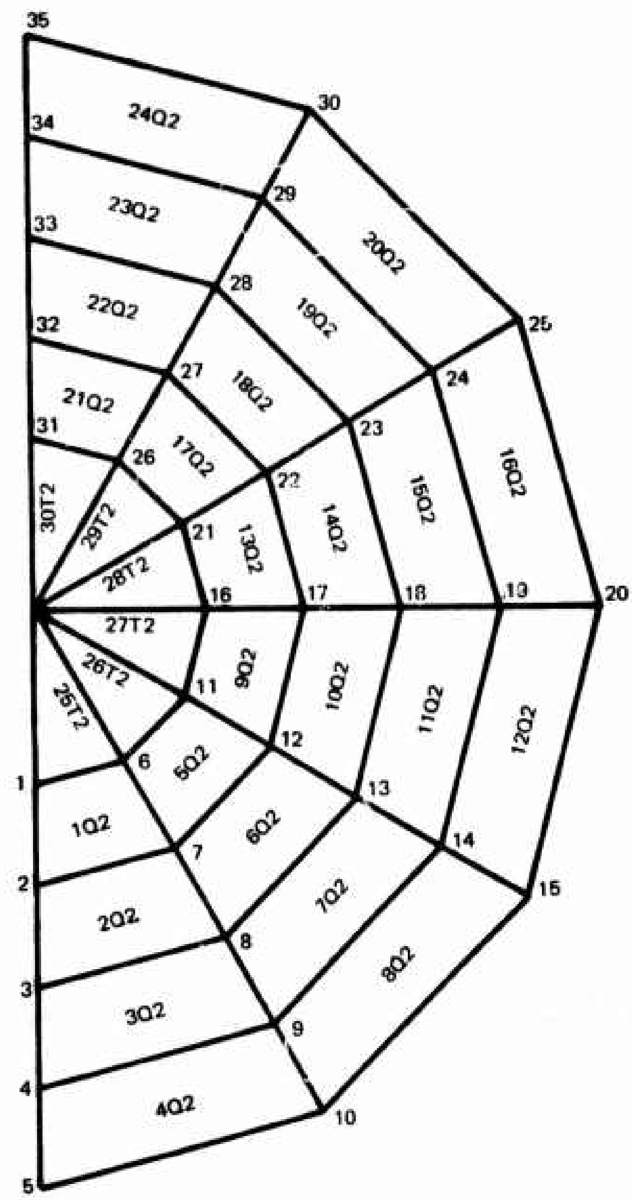


FIG. 4-15. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Forward Dome).

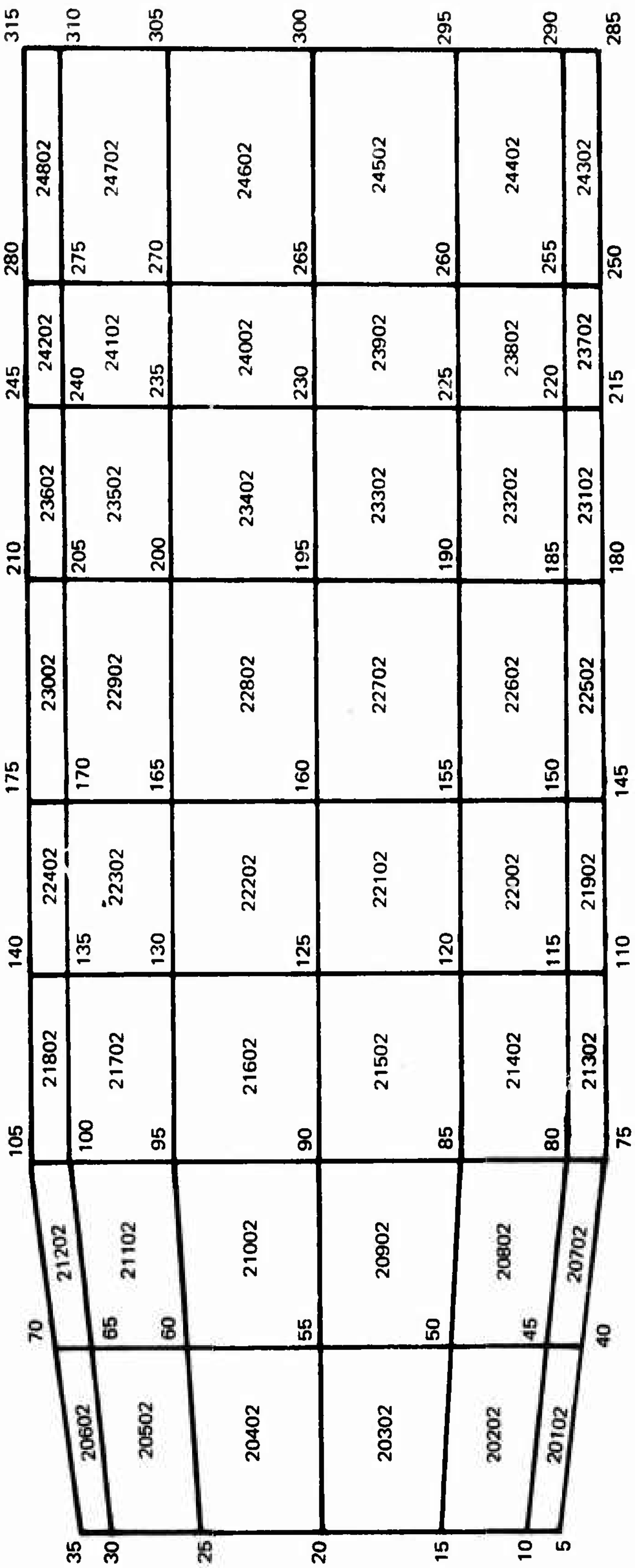


FIG. 4-16. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Side Elevation).

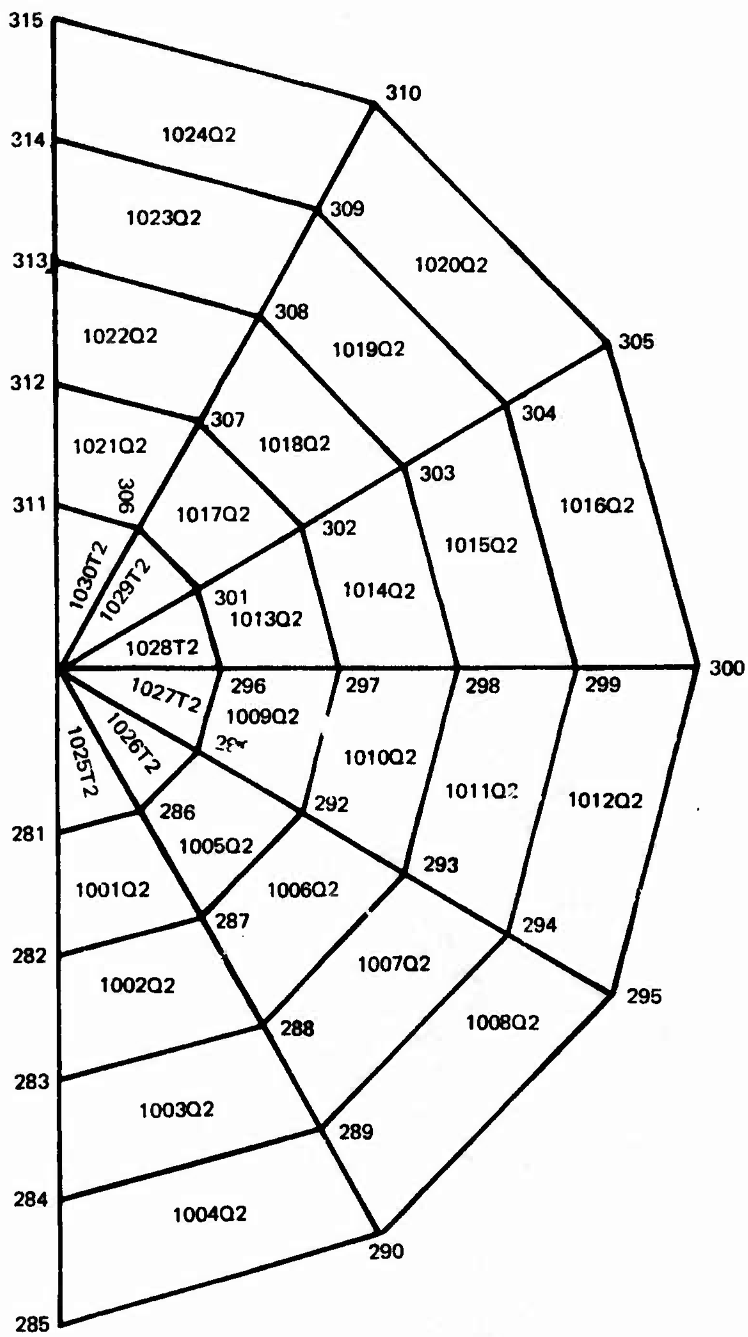


FIG. 4-17. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Aft Dome).

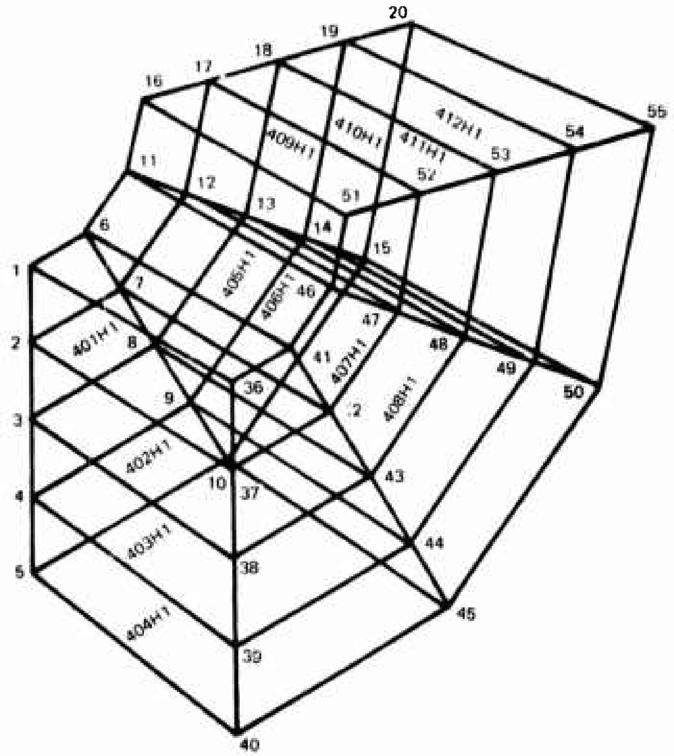


FIG. 4-18. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (First Fluid Section).

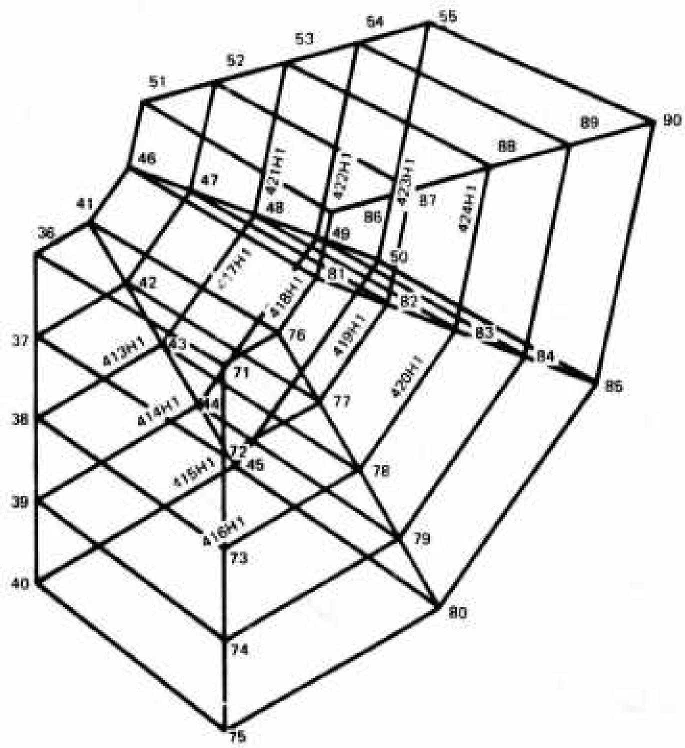


FIG. 4-19. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Second Fluid Section).

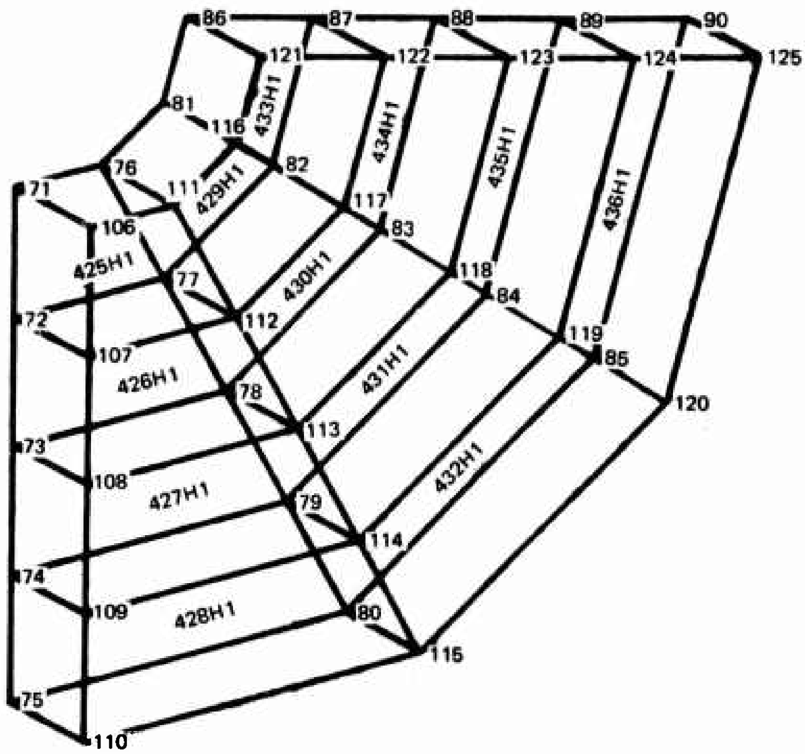


FIG. 4-20. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Third Fluid Section).

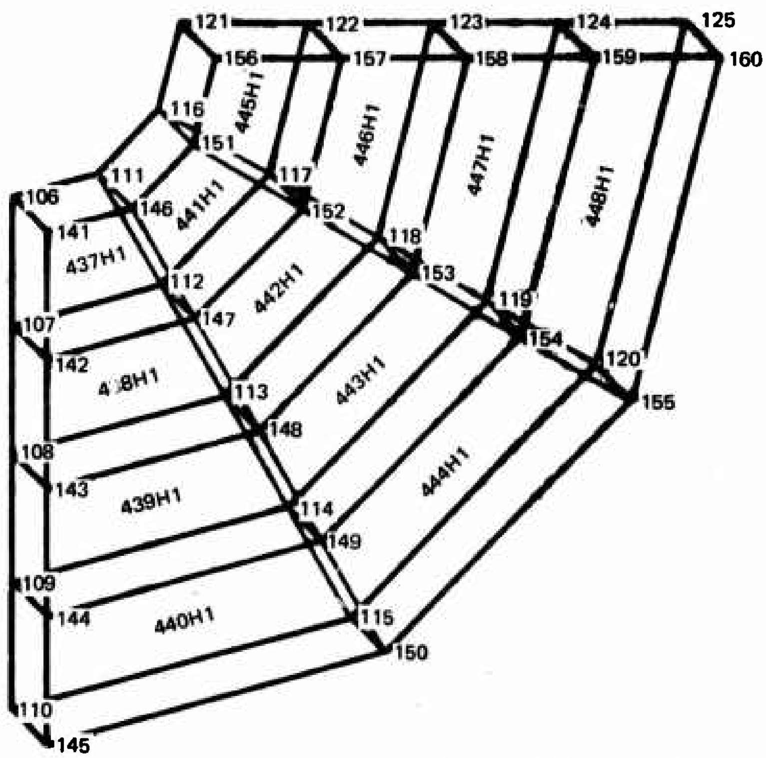


FIG. 4-21. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Fourth Fluid Section).

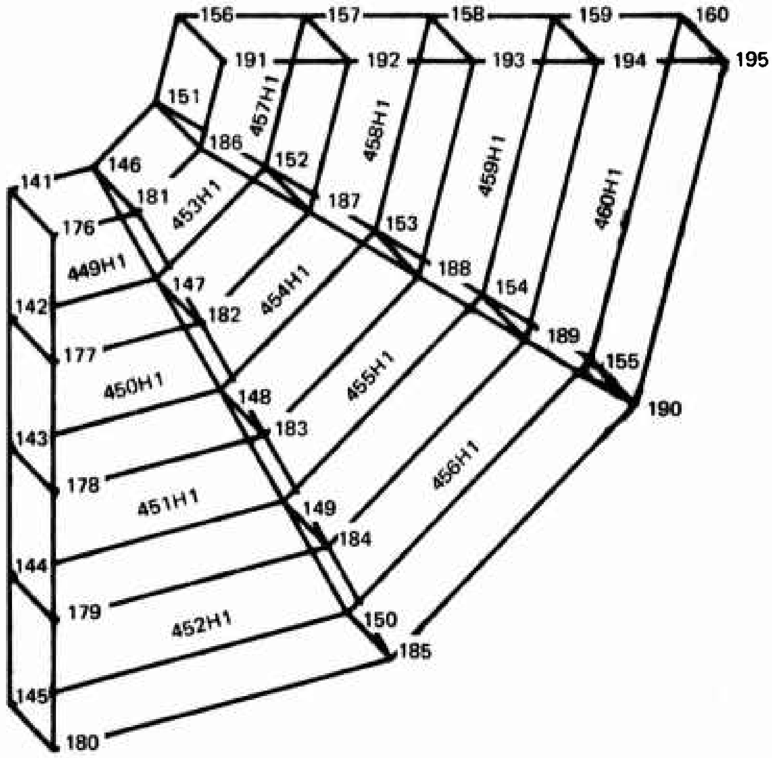


FIG. 4-22. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Fifth Fluid Section).

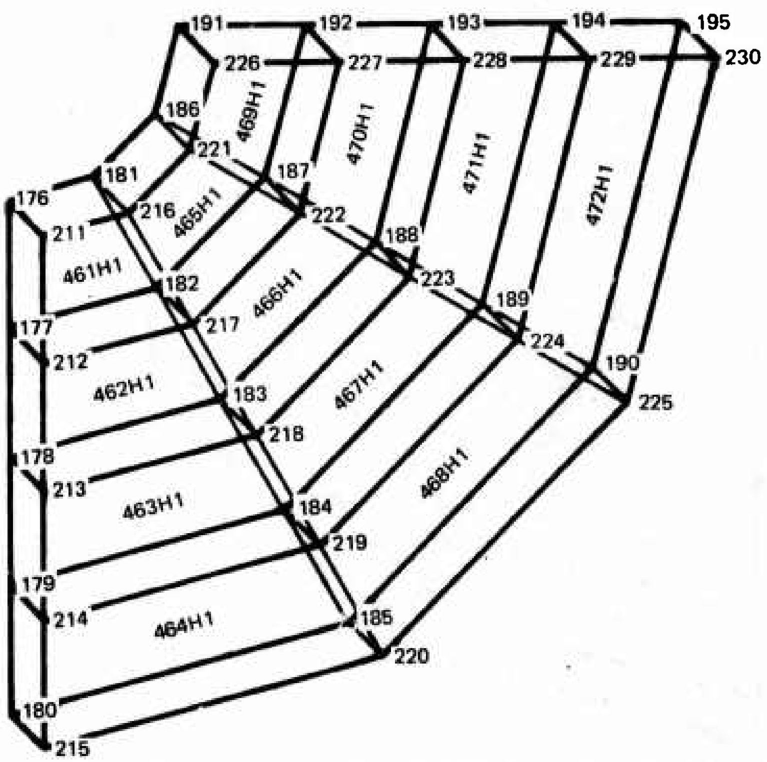


FIG. 4-23. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Sixth Fluid Section).

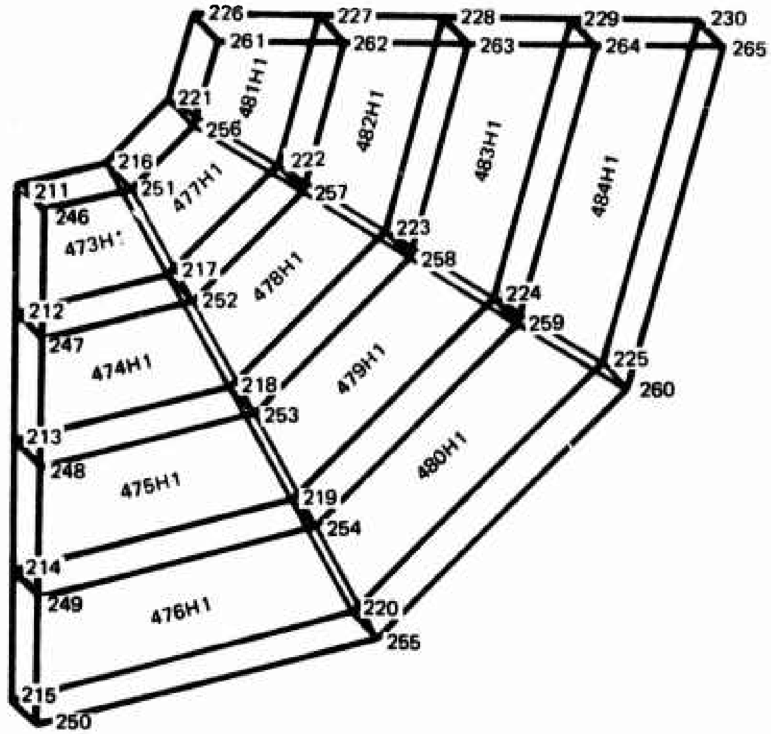


FIG. 4-24. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Seventh Fluid Section).

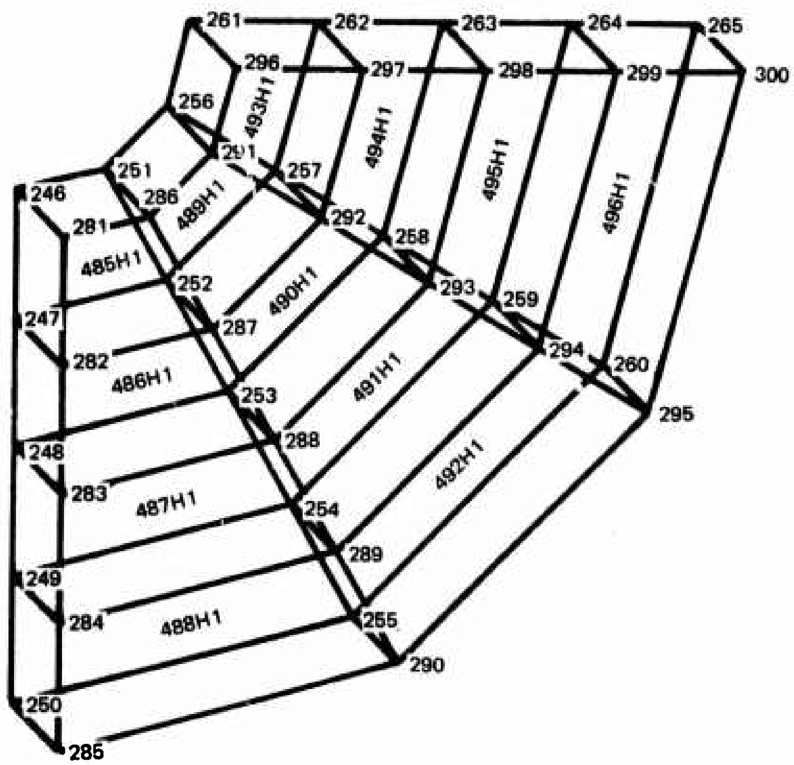


FIG. 4-25. Vibration Study of GORJE Tank - Modes of Half-Filled Tank, Undeformed Shape (Eighth Fluid Section).

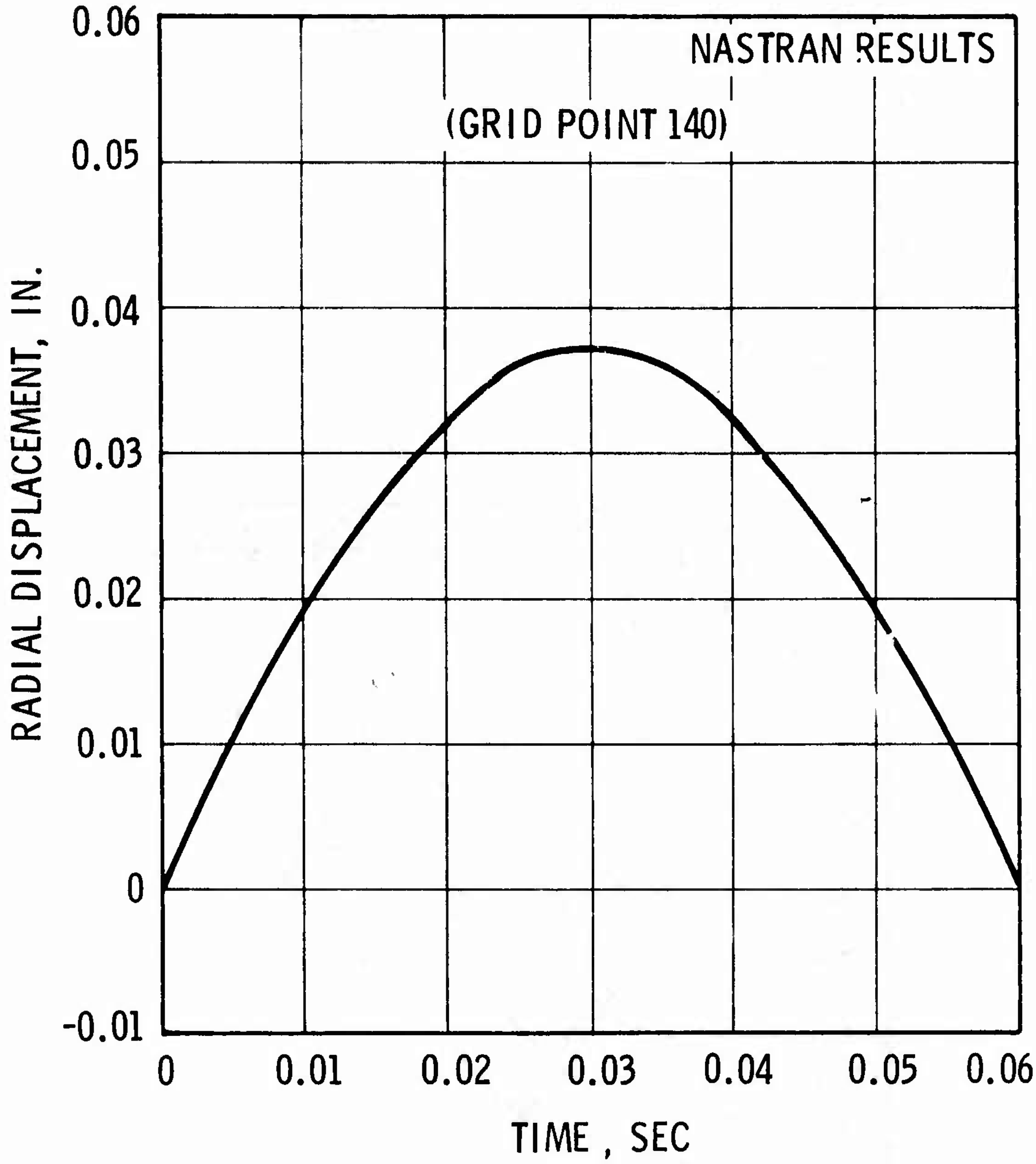


FIG. 4-26. Dynamic Ejection Load, Displacement Under Point of Load.

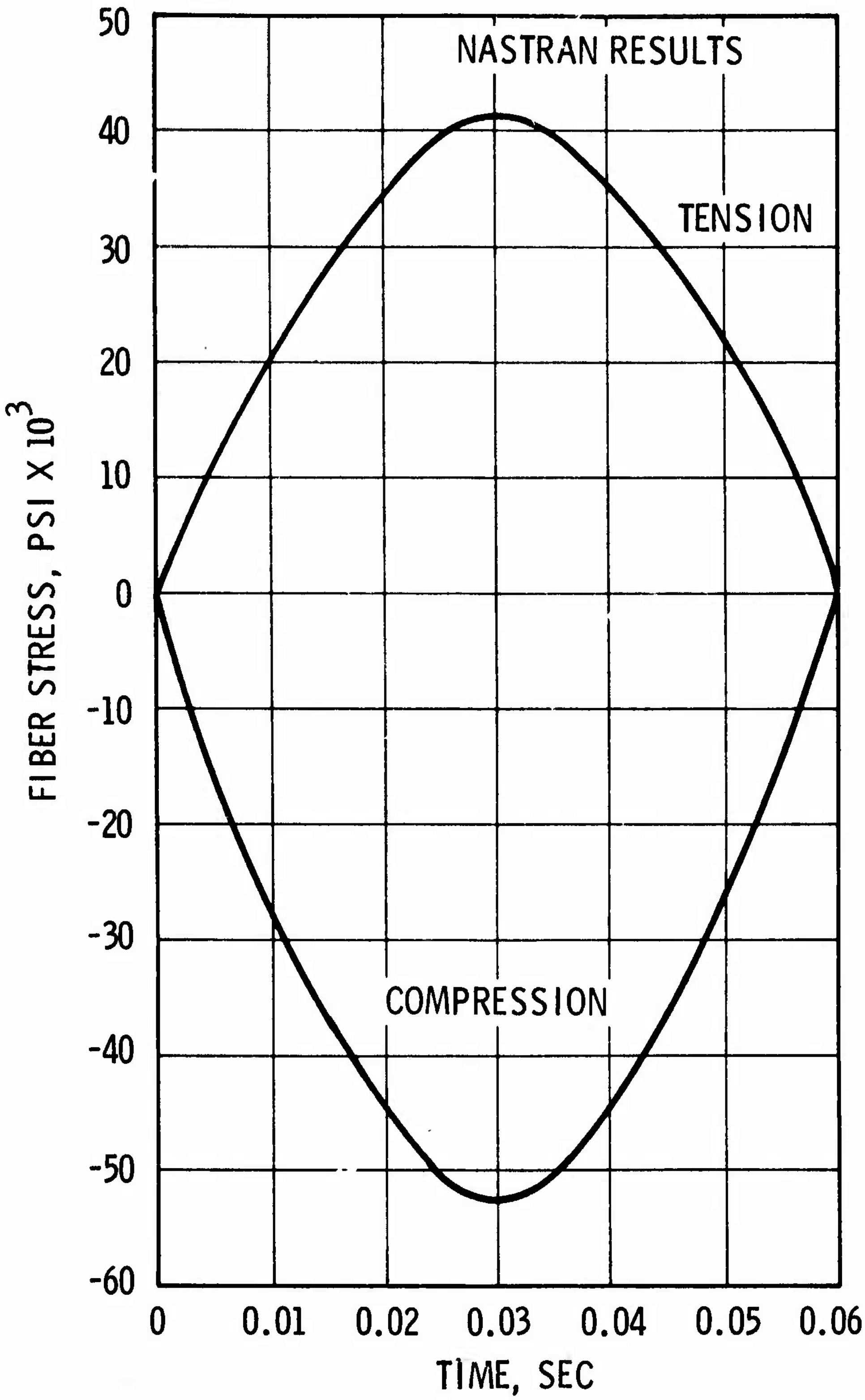


FIG. 4-27. Dynamic Ejection Load, Maximum Stress in Beam Strongback.

FLIGHTWEIGHT TANK ANALYSIS

The 44-pound flightweight design has been checked for the captive flight loads using the same STAGS computer program model as that used on the flight test design. The captive flight loads were the critical loads on the hardware. The reduced basic case wall thickness and reduced strongback cross section increased the strongback deflections and stresses by 25%. Specifically, the maximum radial deflection of the strongback under the 10,000-pound ejection load increased from 0.083 inch for the production design to 0.102 inch for the flight design. The maximum strongback axial stress of 90,000 psi for the production model increased to 114,000 psi. These results still give the required 1.15 safety factor on yield and there is a minimum margin of safety on ultimate load of 0.16. The basic case wall stresses were increased by approximately 9% and the minimum margin of safety remained positive.

The pressurized loading condition was analyzed for the flight design thickness on a final finite element computer run as shown by Fig. 4-8. A STAGS run was made to check the stress developed at the strongback-to-aft closure attachment weld because of pressure loading. The resulting maximum stress in the case wall was 31,000 psi, giving a high margin of safety.

Hence, this analysis shows that the weight reductions for the flightweight design did not make a significant reduction in structural capability from the production model.

5
TANK MANUFACTURING

The GORJE fuel tank assembly manufacturing plan used for fabrication of the ground test and flight test units is described in this section.

Fabrication materials and processes for the ground test and flight test tanks are described in Table 5-1. A flow chart of manufacturing and assembly operations is shown in Fig. 5-1. Photographs of the tank structure during fabrication are presented in Figs. 5-2 and 5-3. A further description is detailed below.

GROUND TEST UNIT AND FLIGHT TEST MANUFACTURING

Tank Structure

The ground test and flight test tanks were manufactured in-house using the CSD manufacturing facilities located at Coyote and Sunnyvale, California. Raw materials used for fabrication were procured from certified suppliers. The forward closure (C11202) and the aft closure (C11201) were machined from 4130 plate per MIL-S-6758 (condition A) because the schedule did not permit procurement of forgings for these components. The parts were rough machined on a tracer lathe, stress relieved, 100% magnetic particle inspected, and machined to final contour. The instrumentation mounting bosses were GTA fusion fillet welded to the forward closure using a locating jig. The aft closure was heat treated per MIL-H-6875 to 140,000/160,000 psi.

The forward conical shell (C11209) was roll formed from 0.060-inch thick 4130 sheet per MIL-S-18729 (normalized), GTA fusion seam welded, stress relieved, 100% magnetic particle inspected, and final machined to print.

The cylindrical shell (C11206) was manufactured using the same processes as the conical shell from 0.060 and 0.090-inch thick 4130 steel per MIL-S-18729 (normalized). The 0.090-inch sheet is used in the zone adjacent to the longeron to provide a transition between the nominal 0.060-inch shell and the thicker longeron.

The longeron (C11204) was rough machined from annealed 4130 steel plate per MIL-S-18729, heat treated per MIL-H-6875 to 140,000/160,000 psi, 100% magnetic particle inspected, and final machined. The forward sway brace ring (C11203) was rough machined from annealed 4130 steel plate per MIL-S-18729, heat treated to 140,000/160,000 psi per MIL-H-6875, magnetic particle inspected, and final machined to drawing requirements.

The remaining fuel tank components (excluding fuel collector pipe and suspension lug details) were the electrical raceway conduits (C11274).

TABLE 5-1. Materials and Processes, GORJE Fuel Tank.

Part No.	Item	Current Materials*	Current Fabrication Process*
C11207	Lug	4340 steel forging MIL-S-5000 (normalized)	Machine: heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI; cadmium plate.
C11218	Shaft	4340 bar per MIL-S-5000 or 4130 bar, MIL-S-6758 (normalized)	Machine; heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI; cadium plate QQ-P-416.
C11217	Sleeve	ASTM A-513 (type 5) (C1010/1020 mild steel tubing)	Machine to length, cadmium plate QQ-P-416.
C11215	Spring, torsion	ASTM A-228 steel wire phosphate coated	Outside procurement per print.
C11216	Spring, lock	17-7 PH sheet per MIL-S-25043 (annealed)	Outside procurement per print.
C11208	Retainer	4130 steel plate per MIL-S-18729 (annealed or normalized)	Machine; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; MPI; cadium plate QQ-P-416.
C11210	Collector pipe assembly (-11-01, -12-01, and -13-01 closures) (-14-01, -15-01 tubing)	304 stainless steel plate QQ-S-766 304 stainless steel tubing MIL-T-8506	Rough machine closure and tubing details; GTA fusion weld; fluorescent penetrant inspect welds/ final machine to print.
C11202	Closure, forward (-11-01) item 5 (-12-01, -13-01, -14-01, -15-01, items 6, 7,8, and 9)	4130 steel plate MIL-S-18729, annealed 4130 steel bar MIL-S-6758, annealed	Details machined to print, items 6,7,8, and 9; GTA fillet weld; MPI; final machined.
C11209	Shell conical (forward)	4130 steel sheet MIL-S-18729 (normalized)	Sheet blank trimmed to size; roll and weld conical section; GTA fusion weld; stress relieve; MPI 100%, final machine to print
C11206	Shell cylindrical -11-01 (0.060 sheet) -12-01 (0.090 sheet)	4130 steel sheet MIL-S-18729 (normalized)	Trim sheet blanks to size; roll-form -11-01 and -12-01 details; GTA fusion butt weld cylinder blanks, stress relieve, 100% MPI; final machine to print.
C11201	Closure, aft	4130 steel plate MIL-S-18729 (annealed)	Rough machine to approximate configuration; heat treat per MIL-H-6875 to 140,000/150,000 psi ultimate; final machine to print, 100% MPI.

TABLE 5-1. (Contd.).

Part No.	Item	Current Materials	Current Fabrication Process
C11204	Longeron	4130 steel plate MIL-S-18729 (annealed)	Rough machine to approximate configuration; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; final machine to print, 100% MPI.
C11203	Ring, forward -15-01, 14-01, 13-01	4130 steel plate MIL-S-18729 (annealed)	Rough machine -15-01 to approximate configuration; GTA weld details, -14-01 and 13-01; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; final machine to print, 100% MPI
C11214	Conduit, tube	4130 steel tubing per MIL-T-6736	Outside procurement; trim to length; form contour to print.
C11224	Weldment, fuel tank (-01-01 assembly)	As described in part numbers below: C11204 longeron C11201 closure, aft C11203 ring, forward C11206 shell, cylindrical C11202 closure, forward C11207 shell, forward C11214 conduit, tube	GTA fusion weld (fillet) longeron to C11203 forward ring and GTA butt weld aft closure to longeron; 100% MPI; assemble two each C11214 conduits in cylindrical shell subassembly; fillet weld to aft closure. GTA fusion girth weld C11207 forward shell to C11202 forward closure to make forward tank subassembly; 100% MPI. Assemble C11206 cylindrical shell over longeron assembly and GTA fusion weld longitudinal and girth seams; 100% MPI. GTA fusion girth weld forward tank subassembly to cylindrical shell subassembly; fillet weld conduit tubes. GTA fusion weld -11-01, -12-01, -13-01, -14-01, and -15-01 of C11224 to C11202 forward closure; 100% MPI. Stress-relief C11224 fuel tank weldment; 100% MPI welds. Clean, degrease, machine final closure bolt hole details, hydrotest.

* Materials and processes used to fabricate ground test units and flight test units; not necessarily the final approach based on design-to-cost.

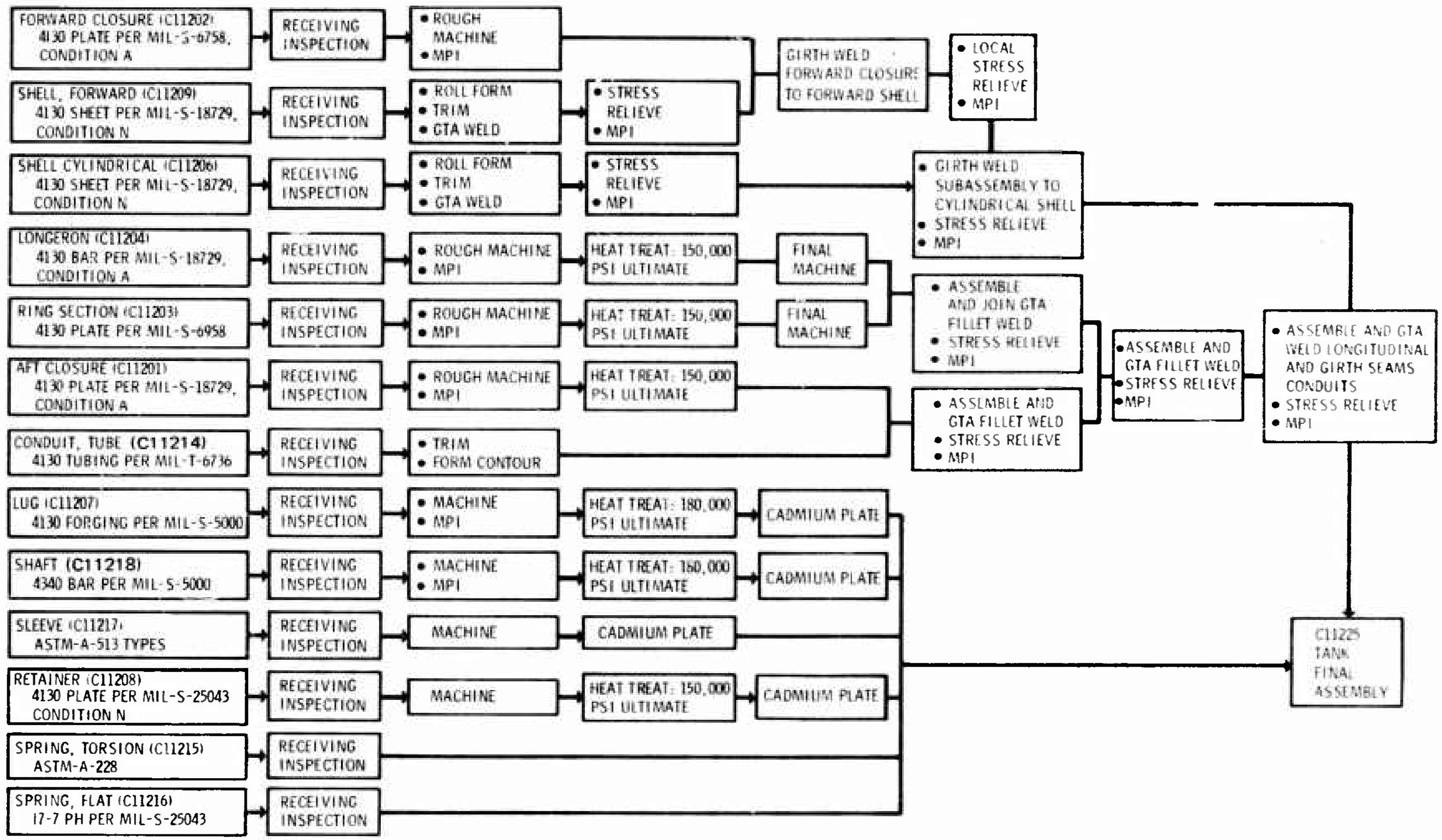


FIG. 5-1. GORJE Ground Test Unit/Flight Test Unit Manufacturing Process Flow Plan.

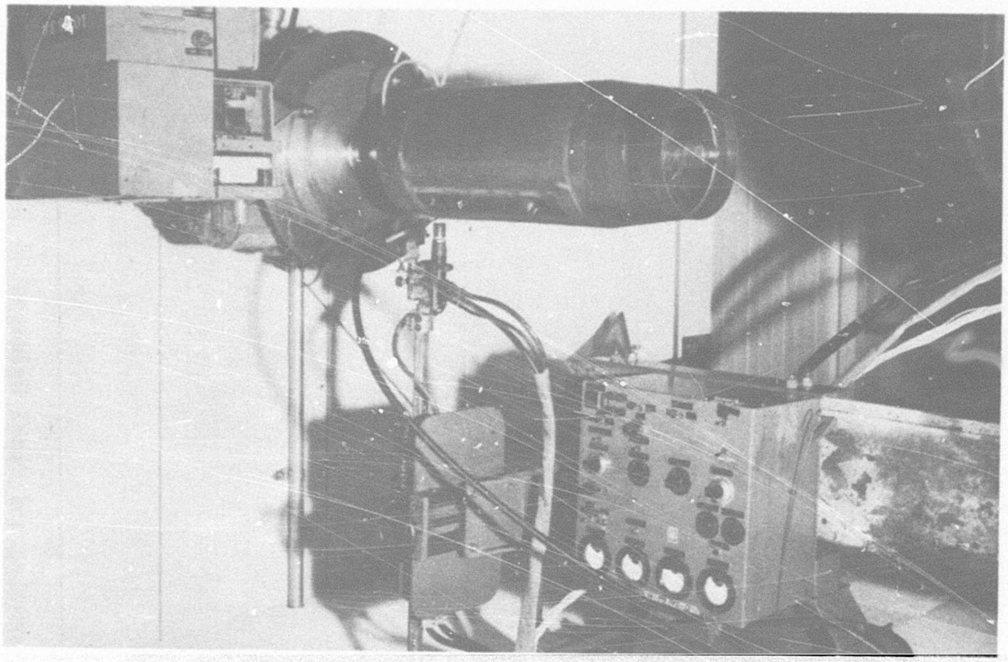


FIG. 5-2. Final Weldment in Semi-Automatic Welder.

These items, fabricated from 4130 steel tubing per MIL-T-6739, were trimmed to length and formed to print contour dimensions.

Fuel tank assembly of the components described above was accomplished by the following weldment procedures:

1. The C11214 conduits were GTA fillet welded to the aft closure, stress relieved, and magnetic particle inspected. Then the C11204 longeron was GTA fusion (fillet) welded to the C11203 forward ring and the C11201 aft closure (with conduits) was GTA fusion butt welded to the longeron using the weld tooling designed and fabricated for this purpose. This weldment subassembly, consisting of forward ring, longeron, aft closure, and conduits, is shown in Fig. 5-3(A).

2. The C11209 forward conical shell was GTA fusion girth welded to the C11202 forward closure, stress relieved, and 100% magnetic particle inspected after welding. The conical shell/forward closure subassembly was GTA fusion girth welded to the C11206 cylindrical shell, stress relieved after welding, and 100% magnetic particle inspected. This weldment subassembly, consisting of forward closure, conical shell, and cylindrical shell, is shown in Fig. 5-3(B).

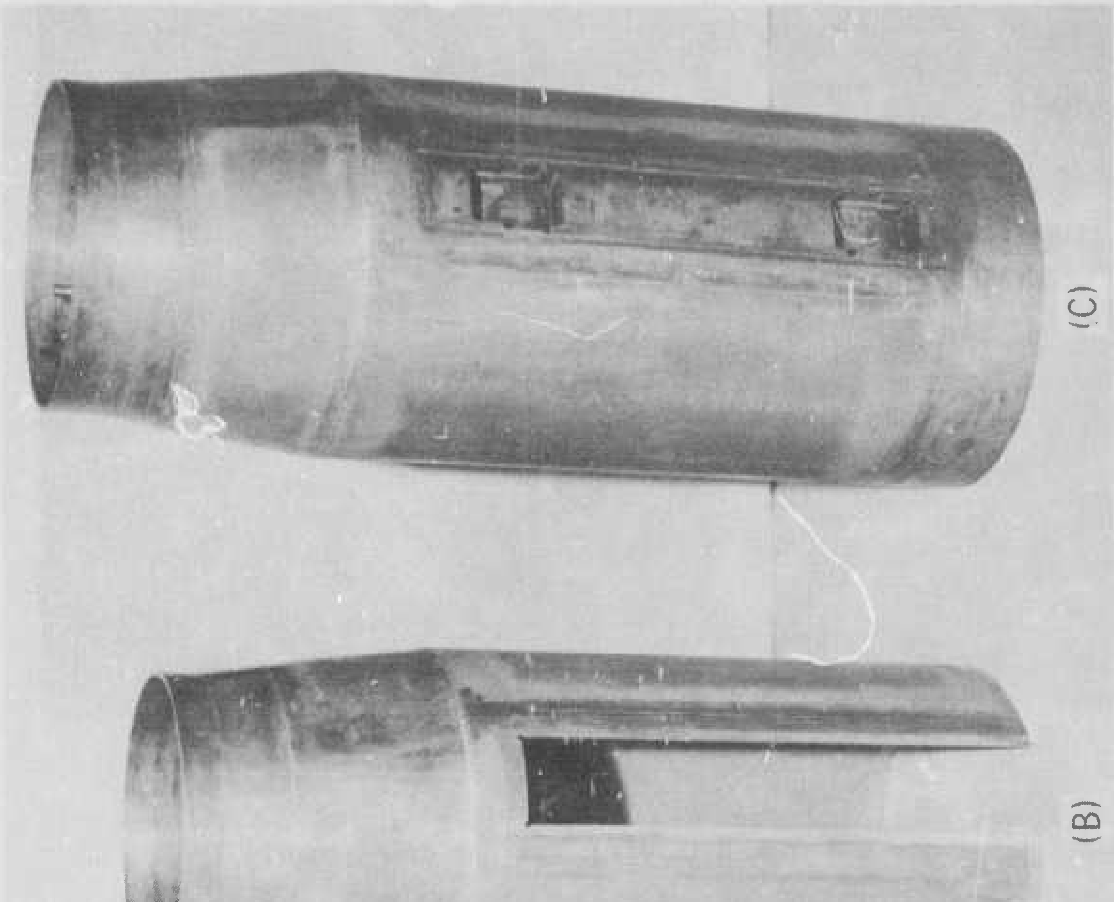


FIG. 5-3. Aft Subassembly, Forward Subassembly, and Final Weldment.

3. Subassembly A (above) was GTA fusion girth welded to subassembly B (above) at the cylindrical shell/aft closure interface, and between the cylindrical shell and the longeron. The conduit tubes were also fillet welded at the forward closure interface. These welding operations are shown in process in Fig. 5-2. Stress relief and 100% magnetic particle inspection of the completed tank weldment was conducted subsequent to completion of all welding operations. The completed weldment is shown in Fig. 5-3(C).

The tank weldment assembly was final machined to incorporate the bolt hole patterns on each closure, the aft closure flange interface for the collector pipe assembly, and the final details on the forward closure instrumentation mounting bosses. Final tank assembly operations consisted of degreasing, cleaning, hydrotest, and inspection.

The tank suspension lug assembly consists of lug, shaft, sleeve, torsion spring, lock spring, retainers, and attach bolts and washers. These components in the assembled configuration are shown in Fig. 3-5. The C11207 lug was machined from a standard 1,000-pound stores suspension lug, 4340 steel forging per MIL-S-5000 (normalized). After machining, the lug was heat treated per MIL-H-6875 to 180,000/200,000 psi ultimate, magnetic particle inspected, and cadmium plated. The suspension lug shaft (C11218) was machined from 4340 steel bar per MIL-S-5000 (normalized), heat treated per MIL-H-6875 to 180,000/200,000 psi ultimate, magnetic particle inspected, and cadmium plated. The sleeve (C11217) was machined from ASTM A-513 mild steel tubing and cadmium plated. The torsion spring was manufactured from ASTM A-228 phosphate coated steel wire by a spring subcontractor. The flat lock spring (C11216) was manufactured from 17-7 PH steel plate per MIL-S-25043 (annealed) and heat treated to condition C950 per MIL-H-6875 by a spring subcontractor. The lug retainers were machined from 4130 steel plate per MIL-S-18729 (normalized), heat treated per MIL-H-6875 to 140,000/160,000 psi ultimate, magnetic particle inspected, and cadmium plated per QQ-P-416.

Expulsion Bladder

Fabrication of the bladder is displayed in the flow diagram (Fig. 5-4). The mandrel washout plaster is prepared with a contour simulating the inside configuration of the bladder. Two plies of the nitrile-coated nylon fabric are vulcanized to the forward and aft bladder flanges between the main attach rings and compression ring. These bonded plies are separated during vulcanization so that the main body plies may be interlocked with them during layup of the bladder.

These forward and aft flanges with bonded flaps are fitted to each end of the washout mandrel and the mandrel surface (excluding flanges) is coated with a release agent. The fittings are prepared and cleaned to facilitate bonding to the bladder. Before being applied to the mandrel, the nylon fabric is swab coated with a thin film of uncured nitrile rubber. Patterns of the fabric are cut to shape from the sheet

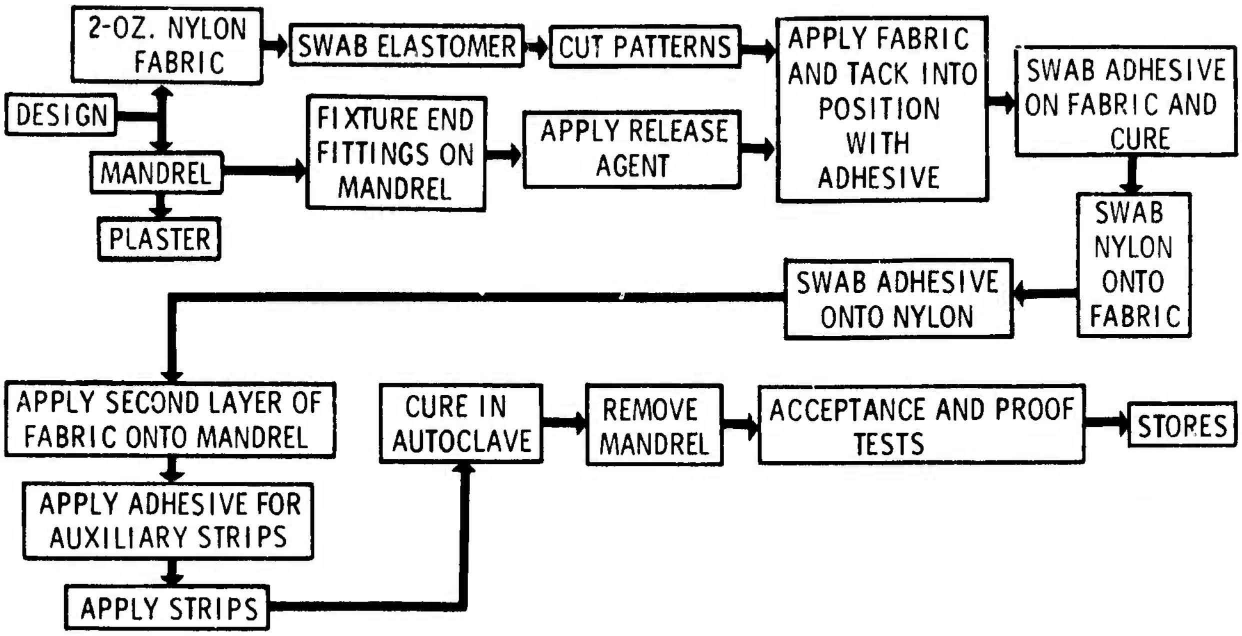


FIG. 5-4. Bladder Fabrication Flow Sheet.

stock, including the stiffener ring and strongback depressions in the mandrel and the main body of the bladder. The patterns at the dome areas are shaped to interlock for added strength. The cut patterns are overlapped a minimum of 1 inch and held in place with a nitrile conversion adhesive. The mandrel is fully covered with one ply of the coated fabric and coated with the adhesive conversion coating. After the adhesive sets, nylon is swabbed onto the entire surface to a minimum 3-mil thickness. Adhesive is again applied and a second layer of fabric applied in the same manner as was the first layer, except that the joint areas are staggered. The longitudinal strips and reinforcements are then applied to complete the assembly.

Curing is accomplished in a steam autoclave at about 60 psi, 290°F for 3 hours. The plaster mandrel is then washed out for removal from the bladder.

Collector Pipe

The collector pipe assembly was designed to use standard off-the-shelf materials and components to provide low cost processing and minimum lead time procurement. Fabrication and operations were coordinated among CSD Manufacturing, Quality Control, and Vendor Liaison departments to assure conformance to design requirements within required delivery schedules.

The collector pipe assembly (see Appendix B, Fig. B-11) consists of (1) the collector pipe, (2) gas generator housing, (3) mounting flange, and (4) forward annulus. The fabrication approach for these components for the ground test unit and flight test units is discussed below.

1. Outer Pipe. Standard weld drawn tubing of 304SS 3-inch OD by 0.065-inch wall, was procured in accordance with MIL-T-8506. The tubing was cut to length, the ends faced, drilled as necessary with 3/16-inch-diameter holes through the wall, cleaned, and stored for subsequent assembly.

2. Gas Generator Housing. Standard weld drawn tubing of 304SS 2-5/8-inch OD by 0.049-inch wall, was procured in accordance with MIL-T-8506. The tubing was cut to length, the ends faced, then cleaned, and stored for later assembly.

3. Mounting Flange. The mounting flange was machined to drawing configuration from 3/4-inch-thick 304SS plate stock. The mounting flange hole pattern was drilled using the same master pattern as for the aft closure of the fuel tank. The flange was then cleaned and stored for later assembly.

4. Closures. The annulus closure was machined from 3-1/8-inch OD by 2-3/8-inch ID 304SS tubing. The gas generator closure was machined from 3-inch-diameter bar stock parted in lengths of 1/2-inch. The standoff was integral with the closure.

The collector pipe assembly sequence is shown in the flow chart of Fig. 5-5. Basically, the assembly is a weldment of the previously described subcomponents. All welds were X-rayed, fluorescent penetrant inspected, and leak checked to ensure a 100% seal.

PRODUCTION TANK MANUFACTURING

Manufacturing options considered for the production tank configuration are listed in Table 5-2. Design changes to the ground test unit/ flight test unit configuration required to meet the flightweight production goal of 44 pounds are listed in Table 5-3.

Bladder

Expulsion bladder fabrication requires the same steps for development as for production; only the methods employed differ. Fabric patterns are hand cut for small quantities whereas automated die cutting is used in production lots. In production, the application of the nitrile to the nylon is automated. Multiple mandrels are processed for production. The hand layup is one constraint; however, it is required in production as well as in development, although jigs and fixtures are used extensively on production to reduce handling time.

Tank Structure

Fabrication materials and fabrication processes for the production tank are described in Fig. 5-6 and in Table 5-4. Some of the processes recommended for production were eliminated during fabrication of the ground test unit and the flight test unit because of the prohibitive

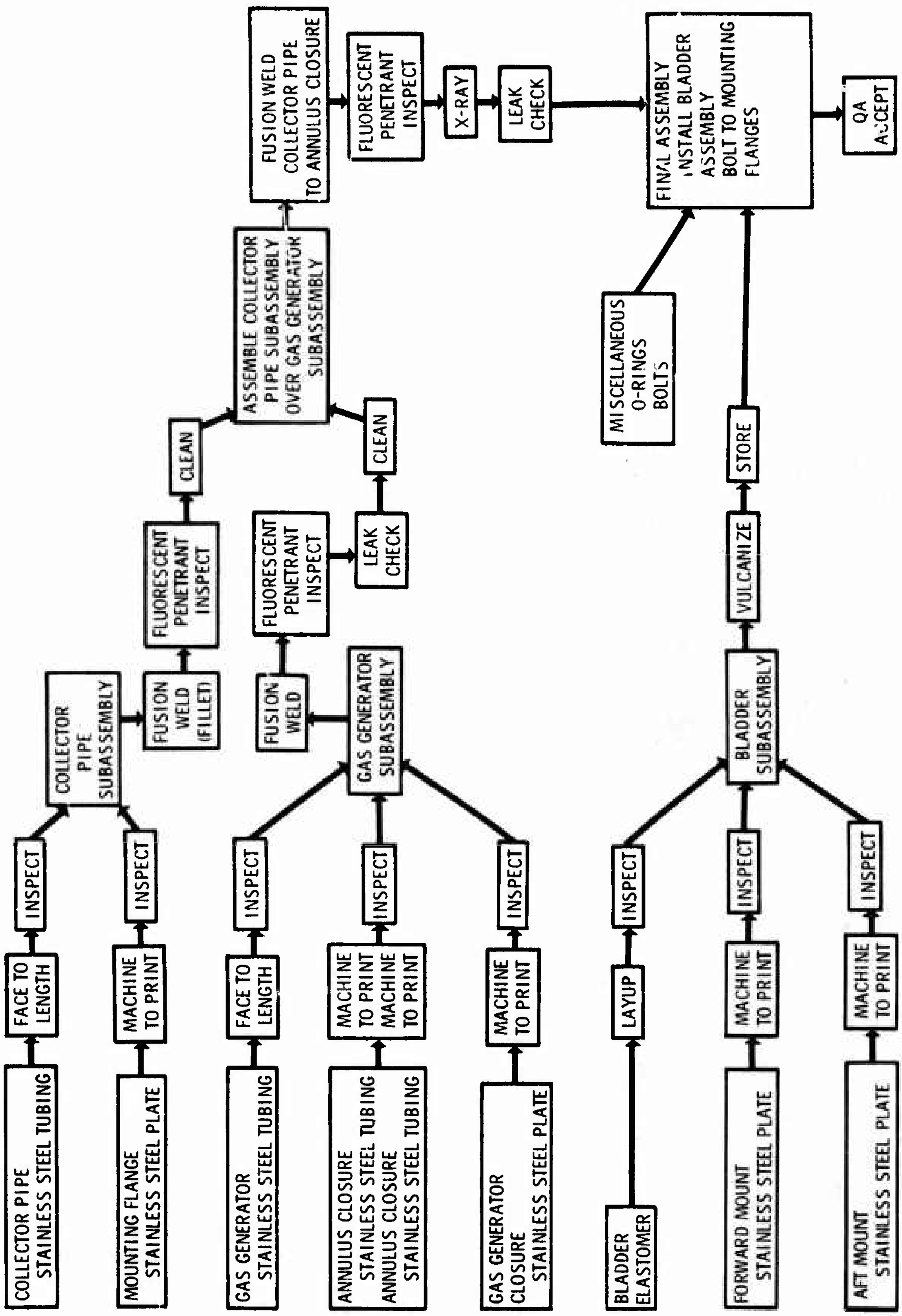


FIG. 5-5. Assembly Sequence, Collector Pipe.

TABLE 5-2. Manufacturing Options for Production Tank Configuration.

Part Number	Manufacturing Options
C11206 Shell, cylindrical	Roll and weld sneet Power (shear)spin cylinder Machined seamless or mechanical tubing Machined forging
C11201 Closure, aft	Machined from forged bar (round) Closed die forged and machined Either the first option or the second with roll and weld skirt Casting
C11203 Ring, forward	Weldment (plate) Forging (die or ring) Extrusion (flash welded ring or doubler) Rolled bar (flash welded ring or doubler) Casting
C11204 Longeron	Weldment Forging (die) Casting Powder Metallurgy
C11202 Closure, forward C11209 Shell, conical	Forged head and skirt welded to roll and weld cone Manual spun head and cone welded to skirt Head and skirt machined from plate welded to roll and weld cone Hydroformed head and cone welded to skirt Deep drawn head and cone welded to skirt Power (shear) spun using die forged or machined preform (no welds) Casting

TABLE 5-3. GORJE Weight Summary.

Component	Ground Test Unit/Flight Test Unit, lb (Estimated)	Flight Production, lb	Remarks
Longeron (C11204)	7.8	7.29	Add holes along neutral axis
Ring (C11203)	4.5	3.67	Asymmetrical casting
Closure, forward (C11202)	6.7	6.27	Reduce wall thickness
Closure, aft (C11201)	10.8	10.1	Reduce wall thickness
Cylinder (C11206) Conical (C11209)	14.7	12.8	Reduce thickness to 0.05 in.
Suspension lug components	2.0	2.0	Minimum weight design
Conduits (C11214)	1.0	1.0	Fixed by NWC requirement
Total (actual)	47.5	44.0	

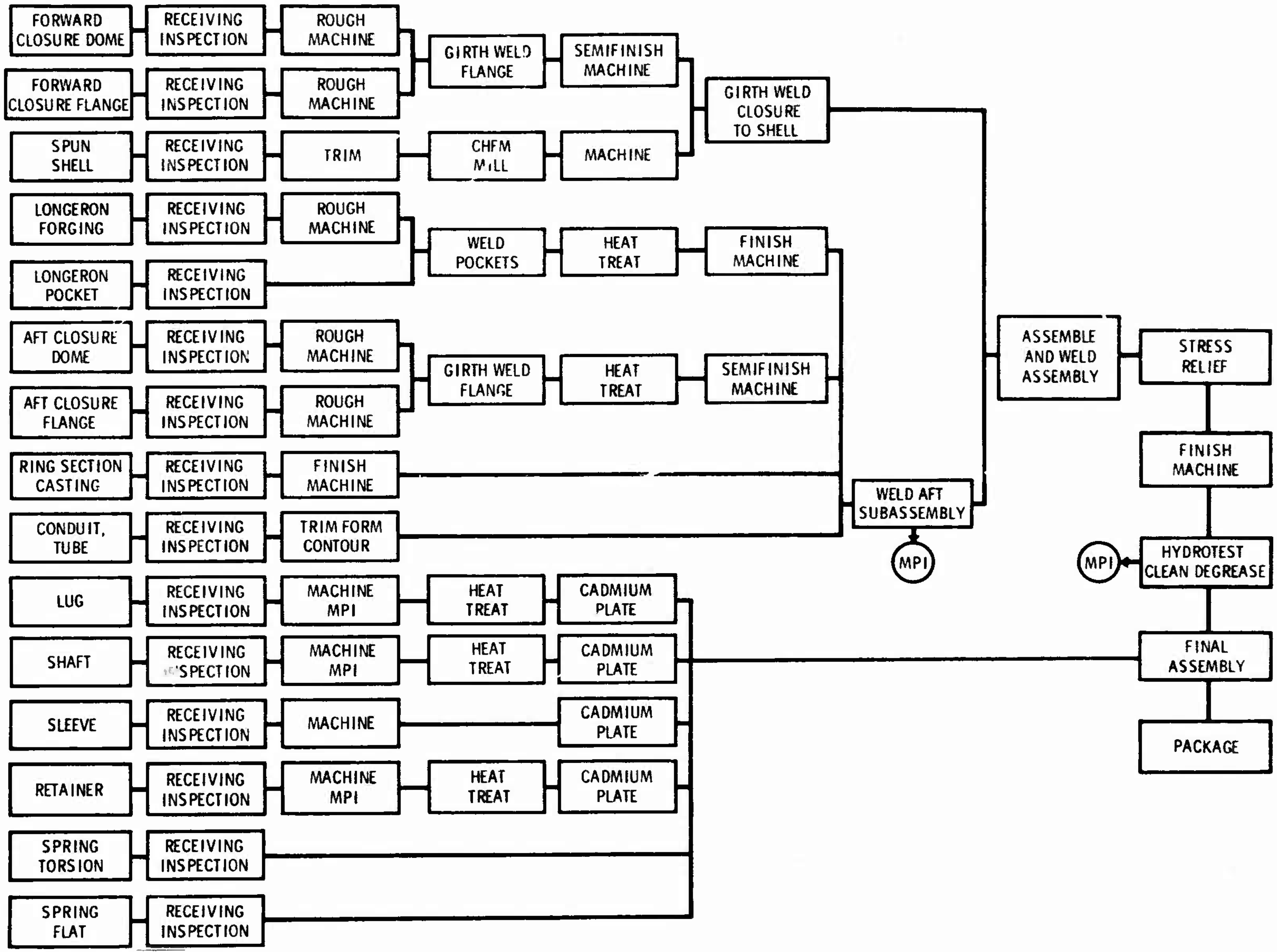


FIG. 5-6. GORJE Production Tank Manufacturing Process Flow Plan.

TABLE 5-4. Material and Processes, GORJE Fuel Tank Production Unit.

Part No.	Item	Material	Fabrication Process
C11207	Lug	4340 steel forging MIL-S-5000 (normalized)	Machine; heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI, cadmium plate.
C11218	Shaft	4340 bar per MIL-S-5000 or 4130 bar, MIL-S-6758 (normalized)	Machine; heat treat per MIL-H-6875 to 180,000/200,000 psi ultimate; MPI; cadmium plate, QQ-P-416.
C11217	Sleeve	ASTM A-513 (type 5) (C1010/1020 mild steel tubing)	Machine length, cadmium plate, QQ-P-416.
C11215	Spring, torsion	ASTM A-228 steel wire phosphate coated	Outside procurement per print.
C11216	Spring, lock	17-7 PH sheet per MIL-D-25043 (annealed)	Outside procurement per print.
C11208	Retainer	4130 steel plate per MIL-S-18729 (annealed or normalized)	Machine; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; MPI; cadmium plate, QQ-P-416.
C11210	Collector pipe assembly (-11-01, -12-01, and -13-01 closures) (-14-01, -15-01 tubing)	304 stainless steel plate QQ-S-766 304 stainless steel tubing MIL-T-8506	Rough machine closure and tubing details; GTA fusion welds; fluorescent penetrant inspect welds/final machine to print.
C11202	Closure, forward	4130 steel plate MIL-S-18729 (annealed) 4130 steel forging MIL-S-6758 (annealed)	Rough machine dome forging and flange; GTA fusion weld; final machine.

TABLE 5-4. (Contd.)

Part No.	Item	Material	Fabrication Process
C11209/ C11206	Shell conical/ cylindrical	4130 steel plate MIL-S-18729 (normalized)	Sheet blank trimmed to size; roll and weld; spin to shape; trim; chem mill; final machine to print.
C11201	Closure, aft	4130 steel plate MIL-S-18729 (annealed) 4130 steel forging MIL-S-6758 (annealed)	Rough machine dome forging, and flange; GTA fusion weld; heat treat per MIL-H-6875 to 140,000/ 150,000 psi ultimate; final machine to print.
C11204	Longeron	4130 forging MIL- - (annealed) 4130 powder metallugy formed pocket	Rough machine longeron forging; GTA weld punch load webs; GTA weld pocket; heat treat per MIL-H-6875 to 140,000/160,000 psi ultimate; final machine to print.
C11203	Ring, foward	4330 steel casting MIL-S-15083; heat treated per MIL-H-6875 to 140/150 ksi ultimate	Final machine to print.
C11214	Conduit, tube	4130 steel tubing per MIL-T-6736	Outside procurement to trim length; form contour to print.
C11224	Weldment, fuel tank (-01-01 assembly)	As described in part numbers below: C11204 longeron C11201 closure, aft C11203 ring, forward C11206 shell, conical C11207 shell, cylindrical	GTA fusion weld (fillet) C11204 longeron to C11203 forward ring and GTA butt weld aft closure to longeron; assemble two each C11214 conduits; fillet weld to aft closure to make aft tank subassembly; 100% MPI.

TABLE 5-4. (Contd.)

C11224, contd.		C11202 closure, forward C11214 conduit, tube	GTA fusion girth weld C11206/ C11207 shell, conical/cylindrical, to C11202 forward closure to make forward tank subassembly. Assemble forward tank subassembly and aft tank subassembly; GTA fusion weld longitudinal and girth seams; fillet weld conduit tubes. Stress-relief C11224 fuel tank weldment; 100% MPI welds. Clean; degrease; machine final closure interface diameter and bolt hole details; hydrotest.

cost of tooling for these processes. The significant material changes recommended for production lots, nominally in excess of 500 units, are as follows: (1) closures fabricated from a net forged dome with a welded flange; (2) tank shell (conical and cylindrical section) shear spun as a single detail and chemically milled to achieve the 0.090 to 0.060 transition in the area of the longeron; (3) a cast variable cross-section sway brace ring; and (4) a forged or extruded longeron with welded load webs and welded powder metallurgy formed lug pockets. These processes, particularly the chemical milling and the powder metallurgy-formed lug pockets, will require some additional development.

The production collector pipe will be fabricated from 304 stainless steel tubing. The outer pipe will be machined from 3.0-inch OD by 0.035-inch wall tubing and the gas generator housing (inner pipe) from 2.625-inch OD by 0.049-inch wall tubing.

The collector pipe mounting flange (C11210-11-01) and gas generator forward closure (C11210-12-01) will be machined from either casting or forging stock instead of plate to minimize machining requirements. The annulus closure(C11210-13-01) will be machined from 3 1/8-inch OD by 2 3/8-inch ID tubing. All other manufacturing operations will be the same as used for the flight test collector pipe fabrication.

PRODUCTION TANK MANUFACTURING COST ANALYSIS

A manufacturing cost analysis was conducted for the production tank configuration.

Expulsion Bladder

Subcontract manufacturing costs were acquired for manufacture of the nylon reinforced nitrile expulsion bladder. Cost tradeoffs were made for the following design deletions.

1. Removal of external strips that assist in bladder venting. The bladder can probably be used minus venting strips without causing a performance penalty.

2. Removal of the circumferential depression used to accommodate the sway brace ring and the longitudinal depression used to accommodate the longeron and raceway tubes. Development testing has indicated that the bladder will probably bridge these areas without failure during flight loads. However, a 3% to 5% decrease in volumetric efficiency can be expected.

3. Removal of metallic polar fittings. The metallic polar fittings could be replaced with fittings used to sandwich the bladder to the collector pipe during assembly; however, a decrease in reliability in regard to a potential leakage at the polar interface can be expected.

A cost summary for the baseline bladder and the three options is shown in Table 5-5.

Tank Metal Structure

The manufacturing cost analysis for the metal tank structure and collector pipe is presented in Tables 5-6 through 5-27.

Cost trades were made in the following areas:

Forward Closure. A comparison of Tables 5-6 and 5-7 shows that the forged closure with welded ring is a lower cost manufacturing approach than a one-piece forged ring closure.

TABLE 5-5. Bladder Cost Summary (Including Tooling).

Bladder Configuration	No. of Units (Cost/Unit) $		
	500	1,000	2,000
Baseline bladder	710	680	673
No venting strips.	695	665	658
No depressions	682	652	645
No polar fitting	625	595	588
All deletions included . .	582	552	545

Aft Closure. A comparison of Tables 5-8 and 5-9 shows that a forged aft closure with welded flange is a lower cost manufacturing approach than a one-piece forged ring closure.

Longeron. A comparison of Tables 5-10 and 5-11 shows that a forged bar longeron with welded powder metallurgy pocket is a lower cost manufacturing approach than a longeron machined from bar stock, even though the initial tooling cost is much higher.

Sway Brace Ring. A comparison of Tables 5-12 and 5-13 shows that a cast and heat treated sway brace ring is a lower cost manufacturing approach than a forged ring.

Tank Skin. Four approaches were analyzed for the tank skin fabrication, as shown in Tables 5-14 through 5-17:

1. Spun section with chemical milled stiffener
2. Spun section with welded stiffener
3. Rolled and welded section with welded stiffener
4. Rolled and welded section with chemical mill stiffner

The spun section with chemical milled stiffener is the lowest cost manufacturing approach for 500 or more units. The spun section with welded stiffener section is less expensive for 50 or less units.

Miscellaneous Hardware. Costs per tank for miscellaneous hardware including suspension lugs are presented in Table 5-18.

Forward, Aft, and Final Assembly Weldments. Unit costs for forward, aft, and final assembly weldments are shown in Tables 5-19 through 5-21.

Final Machining. Final machining unit costs are shown in Table 5-22.

Collector Pipe. Manufacturing costs for the collector pipe are shown in Table 5-23.

Tooling. The unit tooling costs for the tank and collector pipe are summarized in Table 5-24. These costs are detailed in previous tables.

Tank Manufacturing Materials and Labor. A summary of tank unit material and labor requirements is presented in Table 5-25. The labor requirements, converted into dollars at $25/hour for manufacturing and $30/hour for engineering and quality support, are summarized in Table 5-26.

Total unit costs including labor, materials, and tooling are presented in Table 5-27.

Tank Assembly Cost. Total tank assembly unit costs including the baseline bladder configuration and collector pipe are as follows.

No. of Units	50	500	1,000	2,000
Assembly unit cost, $	5,767	2,576	2,247	1,943

These costs represent a 44-pound tank with a 76-pound TH-Dimer fuel capacity.

The effect of tank weight on cost has been analyzed for the following conditions:

1. Use of 1020 mild steel for the tank shell
2. Use of 1020 mild steel for the complete tank assembly
3. Use of net forged closures and longeron with no contour finish machining
4. Use of constant cylindrical shell thickness in conjunction with 2 above.

All of these changes will result in a weight increase over the baseline design. Lighter tank configurations were not analyzed because the baseline design incorporates all practical approaches to weight reduction without the use of exotic materials or manufacturing processes with attendant large increase in manufacturing costs.

Use of the 1020 mild steel for the tank shell will result in a 10% increase in tank weight with a negligible decrease in materials and manufacturing costs.

Use of the 1020 mild steel for the complete tank assembly will increase tank weight over 100% with a reduction in manufacturing cost of less than 10%.

Use of 4130 steel forward and aft closures and longeron in the net forged condition will result in a tank weight increase of over 50% with less than a 10% reduction in manufacturing costs.

Use of a constant tank shell thickness (no chemical milling) will result in a tank weight increase of 15% to 20% with a manufacturing cost reduction of less than 2%.

Examination of these options shows that the possible methods of manufacturing cost reduction are not worth the weight penalty.

An increase in tank volume over the baseline design can be achieved by increasing the ellipse ratio of the closures. The maximum possible volume increase with flat closures will result in a volume increase of less than 3% with a negligible cost increase; however, a large increase in tank weight will result. The baseline design is considered optimum from the cost versus volume standpoint. The effect of bladder volume versus cost is discussed at the beginning of this section.

TABLE 5-6. Forged Forward Closure with Welded Flange.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture, ring	900	900	900	900
Lathe fixture, dome	800	800	800	800
Weld fixture	1,500	1,500	1,500	1,500
Forging tooling	6,500	6,500	6,500	6,500
Drill fixture	700	700	700	700
Total	10,400	10,400	10,400	10,400
Unit cost	208	20.80	10.40	5.20
Material, $				
Dome forging	42.56	38.59	36.75	35.00
Ring	5.00	5.00	5.00	5.00
Total	47.56	43.59	41.75	40.00
Labor, hr	166	1,166	2,100	3,779
Weld preparation, ring				
Weld preparation, dome				
Weld assembly				
Semi-finish machine				
Drill pilot holes				
Total	166	1,166	2,100	3,779
Unit cost				
Material and tooling, $	255.56	64.39	52.15	45.20
Labor, hr	3.32	2.33	2.10	1.89
Labor at $25/hr, $	83.00	58.30	52.50	47.24
Total, $	338.56	122.69	104.65	92.44

TABLE 5-7. Forward Closure with Forged Ring.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
ID template, rough	250	250	250	250
OD template, rough	250	250	250	250
ID template, finished	250	250	250	250
OD template, finished	250	250	250	250
Lathe fixture	900	900	900	900
Drill fixture	700	700	700	700
Total	2,600	2,600	2,600	2,600
Unit cost	52	5.20	2.60	1.30
Material, $				
Forged ring	39.83	38.21	38.21	38.21
Total	39.83	38.21	38.21	38.21
Labor, hr	551	3,888	7,000	12,598
Machine OD (20)				
Machine ID				
Drill holes				
Total	551	3,888	7,000	12,598
Unit cost				
Material and tooling, $	91.84	43.41	40.81	39.51
Labor, hr	11.04	7.78	7.00	6.30
Labor at $25/hr, $	276.00	194.00	175.20	157.47
Total, $	369.84	237.41	216.01	196.98

TABLE 5-8. Aft Closure with Forged Ring.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
ID template, rough	250	250	250	250
OD template, rough	250	250	250	250
ID template, finished	250	250	250	250
OD template, finished	250	250	250	250
Lathe fixture	900	900	900	900
Drill fixture	700	700	700	700
Total	2,600	2,600	2,600	2,600
Unit cost	52	5.20	2.60	1.30
Material, $				
Forging	61.40	59.73	59.73	59.73
Heat treat	10	10	9	8
Total	71.40	69.73	68.73	67.73
Labor, hr				
Machine OD (20)	551	3,888	7,000	12,598
Machine ID				
Drill holes				
Total	551	3,888	7,000	12,598
Unit cost				
Material and tooling, $	123.4	74.93	71.33	69.03
Labor, hr	11.04	7.78	7.00	6.30
Labor at $25/hr, $	276.00	194.00	175.00	157.47
Total, $	399.4	268.93	246.33	226.5

TABLE 5-9. Forged Aft Closure with Welded Flange.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture, ring	900	900	900	900
Lathe fixture, dome	800	800	800	800
Weld fixture	1,500	1,500	1,500	1,500
Forging tooling	5,800	5,800	5,800	5,800
Drill fixture	700	700	700	700
Total	9,700	9,700	9,700	9,700
Unit Cost	194	19.40	9.70	4.85
Material, $				
Dome forging	57.89	55.14	53.34	50.00
Ring	5.00	5.00	5.00	5.00
Heat treat				
Total	62.89	60.14	58.34	55.00
Labor, hr	166	1,166	2,100	3,779
Weld preparation, ring (6)				
Weld preparation, dome				
Weld assembly				
Semifinish machine				
Drill pilot holes				
Total	166	1,166	2,100	3,779
Unit cost				
Material and tooling, $	256.89	79.54	68.04	59.85
Labor, hr	3.32	2.33	2.10	1.89
Labor at $25/hr, $	83.00	58.30	52.50	47.24
Total, $	339.89	137.84	120.54	107.09

TABLE 5-10. Longeron, Powder Metallurgy Pocket/Forged Bar.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture	1,000	1,000	1,000	1,000
Pocket mold dies	20,000	20,000	20,000	20,000
Drill jig	600	600	600	600
Total	21,600	21,600	21,600	21,600
Unit cost	432.00	43.20	21.60	10.80
Material, $				
Bar forging	40	40	40	40
Pocket	1	1	1	1
Heat treat	10	10	10	10
Total	51	51	51	51
Labor, hr				
Machine assembly	137	972	1,750	3,149
Weld pocket				
Finish mill pocket				
Drill holes				
Total	137	972	1,750	3,149
Unit cost				
Material and tooling, $	483.00	94.2	72.60	62.80
Labor, hr	2.74	1.94	1.75	1.57
Labor at $25/hr, $	68.50	48.60	43.75	39.36
Total, $	551.5	142.80	116.35	102.16

TABLE 5-11. Longeron, Machined Bar Stock.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture	1,000	1,000	1,000	1,000
Mill fixture	500	500	500	500
Drill jig	600	600	600	600
Total	2,100	2,100	2,100	2,100
Unit cost	42.00	4.20	2.10	1.05
Material, $				
Bar	77	77	77	77
Total	77	77	77	77
Labor, hr	1,379	9,720	17,497	31,494
Mill				
Turn				
Drill				
Weld				
Total	1,379	9,720	17,497	31,494
Unit cost				
Material and tooling, $	119.00	81.20	79.10	78.05
Labor, hr	27.58	19.44	17.49	15.75
Labor at $25/hr, $	689.50	486.00	437.42	394.00
Total, $	808.50	567.20	516.52	471.73

TABLE 5-12. Ring Casting.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture	900	900	900	900
Casting tooling	5,490	5,490	5,490	5,490
Total	6,390	6,390	6,390	6,390
Unit Cost	127.80	12.78	6.39	3.20
Material, $				
Casting (heat treated)	138.60	125.70	119.70	114.00
Total	138.60	125.70	119.70	114.00
Labor, hr	14	97	175	314
Machine OD				
Deburr				
Total	14	97	175	314
Unit cost				
Material and tooling, $	266.40	138.48	126.09	117.20
Labor, hr	0.28	0.194	0.175	0.157
Labor at $25/hr, $	7.00	4.85	4.38	3.93
Total, $	273.40	143.33	100.47	121.13

TABLE 5-13. Ring, Forged.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Lathe fixture	900	900	900	900
Drill fixture	1,200	1,200	1,200	1,200
Total	2,100	2,100	2,100	2,100
Unit cost	42	4.20	2.10	1.05
Material, $				
Forge ring	39.50	39.50	39.50	30.50
Total	39.50	39.50	39.50	39.50
Labor, hr				
Machine OD (16)	441	3,110	5,600	10,080
Drill holes (5)	14	97	175	314
Deburr				
Total	455	3,207	5,775	10,394
Unit cost				
Material and tooling, $	81.50	43.70	41.60	40.55
Labor, hr	9.10	6.42	5.77	5.20
Labor at $25/hr, $	227.60	160.39	144.35	129.91
Total, $	309.10	204.09	185.95	170.46

TABLE 5-14. Skin-Spun Section, Chem Mill Stiffener.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Spinning (tooling and setup)	1,200	1,200	1,200	1,200
Mask (5)	6,250	12,500	12,500	12,500
End plugs (5)	2,500	5,000	5,000	5,000
Baskets	500	1,000	1,000	1,000
Total	10,450	19,700	19,700	19,700
Unit cost	209	39.40	19.70	9.85
Material, $				
Sheet stock 0.090	30	30	30	30
Total	30	30	30	30
Labor, hr				
Mask	55	388	700	1,260
Trim				
Chem mill				
Cut slot				
Total	55	388	700	1,260
Unit cost				
Material and tooling, $	239	69.40	49.70	39.85
Labor, hr	1.10	0.78	0.70	0.63
Labor at $25/hr, $	27.59	19.44	17.50	15.75
Total, $	266.59	88.84	67.20	55.60

TABLE 5-15. Skin-Spun Section, Welded Stiffener.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Spinning (tooling and setup)	1,200	1,200	1,200	1,200
Weld fixture	2,500	2,500	2,500	2,500
Total	3,700	3,700	3,700	3,700
Unit cost	74.00	7.40	3.70	1.85
Material, $				
Spun cylinder	52	48	47	47
Sheet stock 0.060	17	17	17	17
Sheet stock 0.090	3	3	3	3
Total	72	68	67	67
Labor, hr	97	680	1,225	2,205
Cut slot				
Weld				
Total	97	680	1,225	2,205
Unit Cost				
Material and tooling, $	146	75.40	70.70	68.85
Labor, hr	1.94	1.36	1.23	1.10
Labor at $25/hr, $	48.50	34.00	30.75	27.56
Total, $	194.50	109.90	101.45	96.41

TABLE 5-16. Skin-Roll and Weld, Welded Stiffener.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Cone template	200	200	200	200
Weld fixture, circumferential	600	600	600	600
Weld Fixture, longitudinal	1,200	1,200	1,200	1,200
Total	2,000	2,000	2,000	2,000
Unit cost	40	4.00	2.00	1.00
Material, $				
Sheet stock 0.063	20	20	20	20
Sheet stock 0.090	3	3	3	3
Total	23	23	23	23
Labor, hr	276	1,940	3,499	6,299
Shear stock (10)				
Trim stock				
Weld cone				
Weld cylinder				
Weld cone/cylinder				
Cut slot				
Weld stiffener				
Total	276	1,940	3,499	6,299
Unit cost				
Material and tooling, $	63	27	25	26
Labor, hr	5.52	3.88	3.50	3.15
Labor at $25/hr, $	138.00	97.05	87.48	78.74
Total, $	201.00	124.05	112.48	104.74

TABLE 5-17. Skin-Roll and Weld, Chem Mill Stiffener.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Cone template	200	200	200	200
Weld fixture, circumferential	600	600	600	600
Weld fixture, longitudinal	1,200	1,200	1,200	1,200
Masking templates	6,250	12,500	12,500	12,500
End plugs	2,500	5,000	5,000	5,000
Baskets	500	1,000	1,000	1,000
Total	11,250	20,500	20,500	20,500
Unit cost	225	41.00	20.50	10.25
Material, $				
Sheet stock 0.090	30	30	30	30
Total	30	30	30	30
Labor, hr				
Shear stock (12)	331	2,333	4,199	7,559
Trim stock				
Weld cone				
Weld cylinder				
Weld cone/cylinder				
Mask				
Trim				
Chem mill				
Cut slot				
Total	331	2,333	4,199	7,559
Unit cost				
Material and tooling, $	255.00	71.00	50.50	40.25
Labor, hr	6.62	4.67	4.20	3.78
Labor at $25/hr, $	165.50	116.75	105.00	94.48
Total, $	420.50	187.75	155.50	134.73

TABLE 5-18. Miscellaneous Hardware.

	No. of Units			
	100	1,000	2,000	4,000
Tooling, $				
Conduit bending, apply fixture	750	750	750	750
Log holding fixture (mill)	500	500	500	500
Retainer holding fixture (mill)	500	500	500	500
Shaft holding fixture (mill)	500	500	500	500
Total	2,250	2,250	2,250	2,250
Unit cost	22.50	2.25	1.13	0.57
Material, $				
Conduit (2);4130 steel tubing per MIL-T-6736	3.75	3.75	3.75	3.75
Lug (2);4340 steel forging per MIL-S-5000	3.00	3.00	3.00	3.00
Retainer (4) per tank;4130 steel per MIL-S-18729	0.50	0.50	0.50	0.50
Shaft (2);4340 bar per MIL-S-6758	0.10	0.10	0.10	0.10
Torsion spring (2);subcontract spring manufacturer	0.40	0.40	0.40	0.40
Flat spring (2);subcontract spring manufacturer	0.40	0.40	0.40	0.40
Total	8.15	8.15	8.15	8.15
Labor, hr	332	2,096	3,779	7,560
Drill/mill lug (6)				
Form conduit				
Face and mill shaft				
Mill retainers				
Face sleeve				
Total	332	2,096	3,779	7,560
Unit cost				
Material and tooling, $	30.65	10.40	9.28	8.72
Labor, hr	3.32	2.33	2.10	1.89
Labor at $25/hr, $	83.00	58.30	52.50	47.24
Total, $	113.65	68.70	61.78	55.96

TABLE 5-19. Forward Assembly Weldment.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Weld fixture (addition to basic)	250	250	250	250
Lathe fixture	500	500	500	500
Total	750	750	750	750
Unit cost	15	1.50	0.75	0.38
Material, $				
Total	---	---	---	---
Labor, hr	42	290	520	940
Circumferential weld				
Trim				
Total	42	290	520	940
Unit cost				
Material and tooling, $	---	---	---	---
Labor, hr	0.83	0.58	0.52	0.47
Labor at $25/hr, $	20.75	14.50	13.00	11.75
Total, $	35.75	16.00	13.75	12.13

TABLE 5-20. Aft Assembly Weldment.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Weld fixture	800	800	800	800
Total	800	800	800	800
Unit cost	16	1.60	0.80	0.40
Material, $				
Total	---	---	---	---
Labor, hr				
Weld aft closure, longeron, and tubes	55	390	700	1,260
Total	55	390	700	1,260
Unit cost				
Material and tooling, $	---	---	---	---
Labor, hr	1.10	0.78	0.70	0.63
Labor at $25/hr, $	27.50	19.44	17.49	15.75
Total, $	43.50	21.04	18.29	16.15

TABLE 5-21. Final Assembly Weldment.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Weld fixture	800	800	800	800
Total	800	800	800	800
Unit cost	16	1.60	0.80	0.40
Material, $				
Total	---	---	---	---
Labor, hr				
Final closing welds	69	485	870	1,580
Total	69	485	870	1,580
Unit cost				
Material and tooling, $	---	---	---	---
Labor, hr	1.38	0.97	0.87	0.79
Labor at $25/hr, $	34.49	24.26	21.87	19.68
Total, $	50.49	25.86	22.67	20.08

TABLE 5-22. Final Machine.

	No. of Units			
	50	500	1,000	2,000 +3,650 for additional set of tooling*
Tooling, $				
Lathe fixture	900	900	900	900
Drill jig, forward	900	900	900	900
Drill jig, aft	1,250	1,250	1,250	1,250
Stress relief fixture	600	600	600	600
Acceptance gage	5,000	5,000	5,000	5,000
Total	8,650	8,650	8,650	12,300
Unit cost	173.00	17.30	8.65	6.15
Material, $				
Stress relief	10	10	10	10
Total	10	10	10	10
Labor, hr	552	3,590	7,000	12,600
Turn diameters (20)				
Drill forward flange				
Drill aft flange				
Total	552	3,590	7,000	12,600
Unit cost				
Material and tooling, $	183.00	27.30	18.65	16.15
Labor, hr	11.04	7.78	7.00	6.30
Labor at $25/hr, $	275.88	194.41	174.97	157.47
Total, $	458.88	221.91	193.62	173.62

* Additional set of tooling required to increase production rate and reduce labor requirements

TABLE 5-23. Collector Pipe.

	No. of Units			
	50	500	1,000	2,000
Tooling, $				
Drill jig, tube preparation	625	625	625	625
Drill jig, forward flange	500	500	500	500
Drill jig, aft flange	500	500	500	500
Weld fixture, inner tube	900	900	900	900
Weld fixture, outer assembly	900	900	900	900
Total	3,425	3,425	3,425	3,425
Unit Cost	68.48	6.85	3.42	1.71
Material, $				
Aft flange, 6-1/4 in. diameter by 1 in.	10.00	10.00	10.00	10.00
Disc, 3 in. diameter by 0.75 in.	1.50	1.50	1.50	1.50
Forward flange, 3 in. OD by 2.51 in. ID by 1.5 in.	1.00	1.00	1.00	1.00
Tube, 30.0 in by 0.035 in. wall by 26 in.	1.80	1.80	1.80	1.80
Tube, 2-5/8 in OD by 0.049-in. wall by 20 in.	1.60	1.60	1.60	1.60
Total	15.90	15.90	15.90	15.90
Labor, hr	524	3,695	6,650	11,960
Machine flanges, machine end (19)				
Detail, trim tube inner and outer				
Drill outer tube assembly,				
Weld inner weldment assembly,				
and weld final weldment				
Finish machine				
Total	524	3,695	6,650	11,960

TABLE 5-23. (Contd.)

	No. of Units			
	50	500	1,000	2,000
Unit cost				
Material and tooling, $	84.38	22.75	19.32	17.61
Labor, hr	10.48	7.39	6.65	5.98
Labor at $25/hr, $	262.09	184.69	166.22	149.60
Total, $	346.47	207.44	185.54	167.21

TABLE 5-24. Tooling Costs.

	Total Cost, $	Purchased Tooling Cost, $	Fabricated Tooling Cost, $	Fabricated Tooling Cost, hr
Tooling				
Forward closure	10,400	6,500	3,900	156
Aft closure	9,700	5,800	3,900	156
Longeron.	21,600	20,000	1,600	64
Ring	6,390	5,490	900	36
Skin (50 units)	10,450	1,200	9,250	370
Skin (500 to 2000 units)	19,700	1,200	18,500	740
Miscellaneous hardware	2,250	- - -	2,250	90
Forward assembly	750	- - -	750	30
Aft assembly	800	- - -	800	32
Final assembly.	800	- - -	800	32
Final machine (50 to 1,000 units)	8,650	- - -	8,650	346
Final machine (2,000 units).	12,300	- - -	12,300	492
Collector pipe.	3,425	- - -	3,425	137
Totals for 50 units	75,215	38,990	36,225	1,449
Totals for 500 units	84,465	38,990	45,475	1,819
Totals for 1,000 units	84,465	38,990	45,475	1,819
Totals for 2,000 units	88,115	38,990	49,125	1,965
	No. of Units			
	50	500	1,000	2,000
Tooling support, $				
Manufacturing support at 40% fabrication hours . .	580	728	728	786
Tool design at 100% fabrication hours	1,449	1,819	1,819	1,965
QC at 20% fabrication hours	290	364	364	393
Tooling unit cost				
Fabricated at $25/hr	724.50	90.95	45.46	24.56
Support at $30/hr	348.00	43.68	21.84	11.79
Tool design at $30/hr	869.40	109.14	54.57	29.48
QC at $30/hr.	174.00	21.84	10 92	5.90
Totals	2,115.90	265.61	132.79	71.73

TABLE 5-25. Fabrication Labor and Materials.

	No. of Units				
	1	50	500	1,000	2,000
Fabrication labor, hr					
Forward closure	6	3.32	2.33	2.10	1.89
Aft closure	6	3.32	2.33	2.10	1.89
Longeron	5	2.74	1.94	1.75	1.57
Ring	0.5	0.28	0.19	0.18	0.16
Skin	2	1.10	0.78	0.70	0.63
Miscellaneous hardware	6	3.32	2.38	2.90	1.89
Forward assembly	1.5	0.83	0.58	0.52	0.47
Aft assembly	2	1.10	0.78	0.70	0.63
Final assembly	2.5	1.38	0.97	0.87	0.79
Final machining	20	11.04	7.78	7.00	6.30
Collector pipe	19	10.48	7.39	6.65	5.98
Totals	70.5	38.91	27.40	24.67	22.20
Manufacturing support, $ at 40% fabrication hours		15.56	10.96	9.87	8.88
QC at 20% fabrication hours		7.78	5.48	4.93	4.44
Material, $					
Forward closure		47.56	43.59	41.75	40.00
Aft closure		62.89	60.14	58.34	55.00
Longeron		51.00	51.00	51.00	51.00
Ring		138.60	125.70	119.70	114.00
Skin		30.00	30.00	30.00	30.00
Miscellaneous hardware		8.15	8.15	8.15	8.15
Forward assembly		---	---	---	---
Aft assembly		---	---	---	---
Final assembly		---	---	---	---
Final machining		10.00	10.00	10.00	10.00
Collector pipe		15.90	15.90	15.90	15.90
Totals		364.1	344.48	334.84	324.05

TABLE 5-26. Fabrication Costs.

	No. of Units			
	50	500	1,000	2,000
Fabrication cost at $25/hr, $				
Forward closure	83.00	58.30	52.50	47.24
Aft closure	83.00	58.30	52.50	47.24
Longeron	68.50	48.60	43.75	39.36
Ring	7.00	4.85	4.38	3.93
Skin	27.59	19.44	17.50	15.75
Miscellaneous hardware	83.00	58.30	52.50	47.24
Forward assembly	20.75	14.50	13.00	11.75
Aft assembly	27.50	19.44	17.49	15.75
Final assembly	34.49	24.26	21.87	19.68
Final machining	275.88	194.41	174.97	157.47
Collector pipe	346.47	184.69	166.22	149.60
Total	1057.18	685.09	616.68	555.01
Fabrication support, $				
Manufacturing support at $30/hr	466.80	328.80	296.10	266.40
QC at $30/hr	233.40	164.40	148.05	133.20

TABLE 5-27. Fabrication Summary.

	No. of Units			
	50	500	1,000	2,000
Fabrication unit labor, hr				
Tooling fabrication	28.98	3.64	1.82	0.98
Tooling support	11.60	1.46	0.73	0.39
Tool design	28.98	3.64	1.82	0.98
Tooling QC	5.80	0.73	0.37	0.20
Fabrication	38.91	27.40	24.67	22.20
Fabrication support	15.56	10.96	9.87	8.88
Fabrication QC	7.78	5.48	4.93	4.44
Totals	137.61	53.31	44.21	38.07
Fabrication unit cost, $				
Tooling fabrication	724.50	90.95	45.46	24.56
Tooling purification.	779.80	77.98	38.99	19.50
Tool design	869.40	109.14	54.57	29.48
Tool QC	174.00	21.84	10.92	5.40
Material.	364.10	344.48	334.84	324.05
Fabrication	1,057.18	685.09	616.68	555.01
Fabrication support	466.80	328.80	296.10	266.40
Fabrication QC.	233.40	164.40	148.05	133.20
Tool fabrication support. . . .	348.00	43.68	21.84	11.79
Totals	5,017.18	1,866.36	1,567.45	1,369.89

6
TESTING AND RESULTS

This section presents the testing conditions and results for the GORJE tank ground test and flight test units, including bladder development expulsion tests.

The bladder expulsion test procedures and data sheets, and the fuel tank assembly, test, and packing procedures and information are presented as Appendices D and E.

The test logs for the ground test tank (S/N 001), flight test tanks (S/N 002 through 005), the spare collector pipe (S/N 002S) bladder (S/N 007S), and the test bladders are shown in Appendix F.

BLADDER EVALUATION TESTS

The bladder design verification tests were conducted with two tank assemblies. A plexiglass tank was used for the functional fit, expulsion efficiency, life cycle expulsion, and leak tests. The ground test tank was used for high pressure expulsion efficiency tests and verification of fuel capacity requirements.

The bladder assemblies successfully achieved the test objectives and satisfied the requirements.

Test Conditions

Each bladder assembly was processed per the leak test and installation procedure (Table 6-1) and recorded on the data sheet in Appendix F. Two bladder assemblies were also processed per the bladder expulsion test procedure (Table 6-2) and recorded on the data sheet shown below.

BLADDER EXPULSION TEST DATA SHEET

Test data	______________
Bladder S/N	______________
Bladder expulsion cycle	______________
Bladder expulsion pressure	______________
Bladder expulsion time	______________
Pretest expulsion tank empty weight	______________
Expulsion tank loaded weight	______________
Fuel weight	______________
Expelled tank weight	______________
Expelled fuel weight	______________
Expulsion efficienty	______________
Bladder post-test leakage rate	______________
Bladder visual condition	______________
Remarks regarding test procedure	______________

The bladder assembly was visually examined to assure that there were no cracks, delaminations, punctures, or discrepancies before leak check testing.

Fig. 6-1 shows the bladder, with collector pipe, prior to installation into the tank. The basic bladder configuration, as installed in the transparent plexiglass tank before expulsion, is shown in Fig. 6-2. The folding characteristics of the bladder are shown in Fig. 6-3.

Test Equipment

Plexiglass test tank/ground test tank

GN_2 bottle

Vacuum pump

Valves and gages

TABLE 6-1. Bladder Assembly Leak Test and Installation Procedure.

Leak Check Bladder Assembly, P/N C11193-01-01

1. Clean O-rings (4) and O-ring surfaces with a lint-free cloth. Lubricate with grease per MIL-G-4343.

2. Install O-rings P/N 2-037, 2-042, 2-248 to collector pipe and O-ring 2-151 to bladder assembly.

3. Install bladder assembly to collector pipe assembly P/N C11210-01-01. (Note: On bolt hole pattern of collector pipe aft flange, one hole is offset for alignment of bladder to collector pipe.)

4. Install No. 4-30 screws with lock-o-seal P/N 800-530-2, Parker Seal Co., on aft flange. (Lock-o-seal will self-center under screw head with gentle pressure.) Torque to 10 to 12 inch-pounds.

5. Install hydrostatic test fill plug P/N C11223-11-01 (or NWC supplied fuel controller) in aft flange. Secure with retaining ring, P/N N5000-250, Waldes Truarc.

6. Collapse the bladder by hand for ease of installation into the fuel tank. Avoid sharp objects to prevent puncture.

7. Before installation, visually inspect the inside of the fuel tank for cleanliness.

8. Caution: Align the longitudinal indentation of the bladder to IDC of the fuel tank. Slowly insert the collapsed bladder into the fuel tank and secure with 1/4-28 flat head screws through collector pipe flange into tank flange. Torque screws to 70 to 90 inch-pounds.

9. Install a pressure gage and a flow control valve on the hydrotest fill port and a pressure-vacuum gage and a flow control valve on forward dome for backside pressure and vacuum.

10. Pressurize backside of bladder with GN_2 to 40 psig for 2 to 4 minutes to bleed excess air. Close valves on fill port; hold for 5 minutes; check gage for pressure change. When pressure gage on fill port shows zero pressure, bladder shows no leaks and is satisfactory.

11. Alternate leak test method: after pressurizing backside, connect a line on fill port and put line in a beaker of water and check for gas bubble. No bubbles indicate satisfactory bladder.

TABLE 6-1. (Contd.)

Positioning of Bladder in the Fuel Tank

1. With bladder in the collapsed state, fill the bladder with 20 to 30 pounds of fluid and cap off end.

2. with aft end up, slosh fluid around for 30 seconds, then invert (forward end up) and slosh fluid around for another 30 seconds.

3. Place fuel tank in the horizontal position and expel fluid by pressurizing the backside to 40 psig with GN_2. Hold until air is expelled. Disconnect GN_2 line.

4. Connect vacuum line to backside and evacuate to 26 to 30 inches of mercury and close valve. Bladder positioning is complete.

TABLE 6-2. Bladder Expulsion Test Procedure.

1. Install, leak check and position bladder.

2. For plexiglass tank, inspect bladder for proper setting on longeron and forward ring.

3. Fill bladder as follows:

   A. Vertical test position (Fig. 6-4).

      1. Pull vacuum from backside of bladder. Check for proper contact with case.

      2. Fill with H_2O (approximately 90-3/4 pounds); pull vacuum while filling to eliminate folds.

   B. Horizontal test position (Fig. 6-5.).

      1. All valves in OFF position.

      2. Open valves No. 2 and 3.

      3. Start vacuum pump and evacuate backside to 28 inches of Hg.

      4. Open valve No. 4 and equalize the vacuum on both sides of bladder.

      5. Close valve No. 4.

      6. Open valve No. 5 and fill with fluid.

4. Expel H_2O with GN_2 at 25 to 40 psig.

5. Weigh for weight expulsion and record on data sheet.

6. For recycle of test, add 20 to 25 pounds H_2O and pull a vacuum.

7. Cap H_2O port and invert case, slosh H_2O to reposition bladder in case.

8. Set upright again, pull vacuum, and fill bladder with H_2O (repeat steps 3 through 5).

9. Perform leak test on bladder after every third expulsion test: pressurize backside and check H_2O inlet for air leak or pressurize bladder with gage and check for pressure drop.

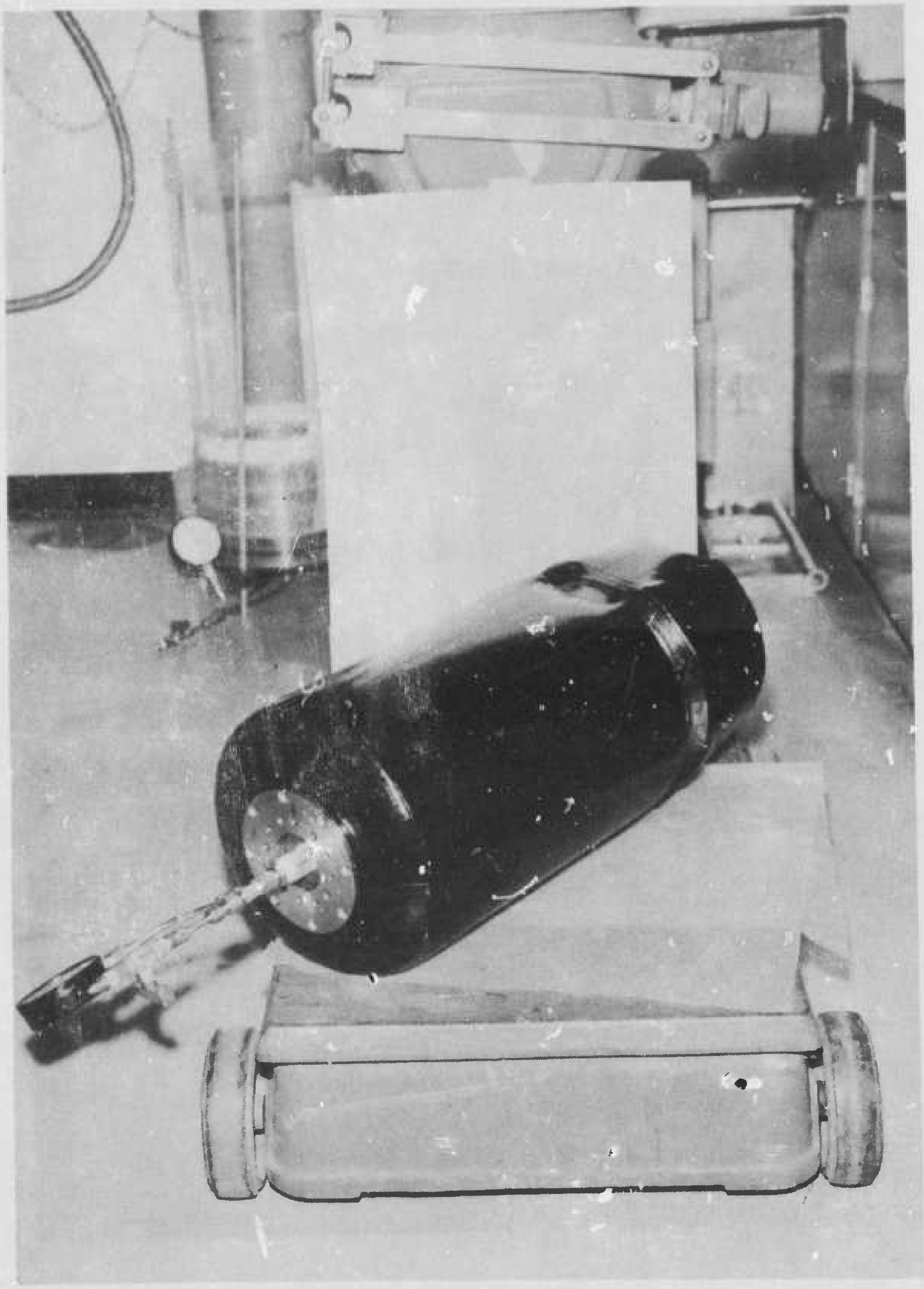


FIG. 6-1. Bladder with Collector Pipe Installed.

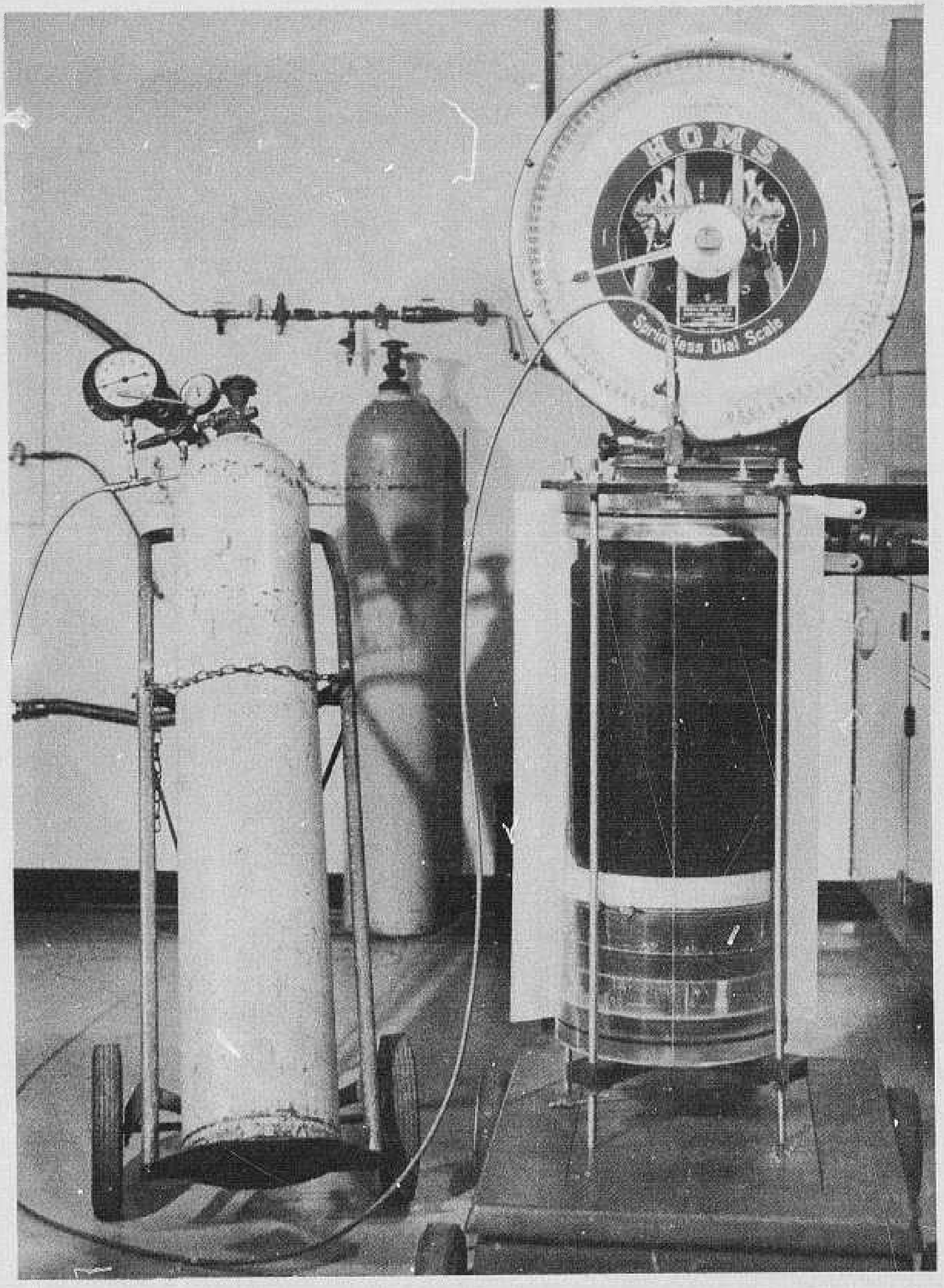


FIG. 6-2. Basic Bladder Configuration.

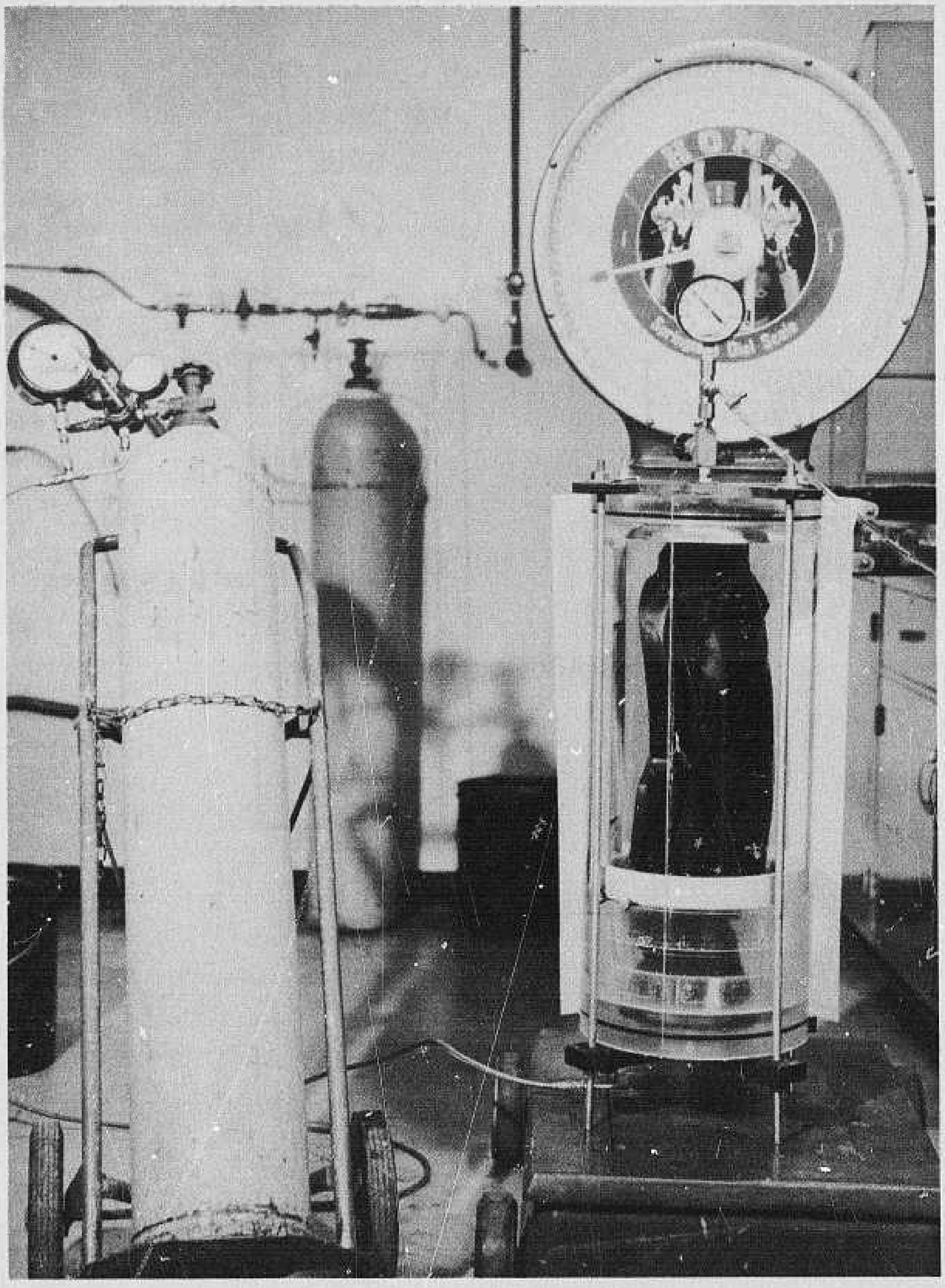


FIG. 6-3. Bladder Folding Characteristics.

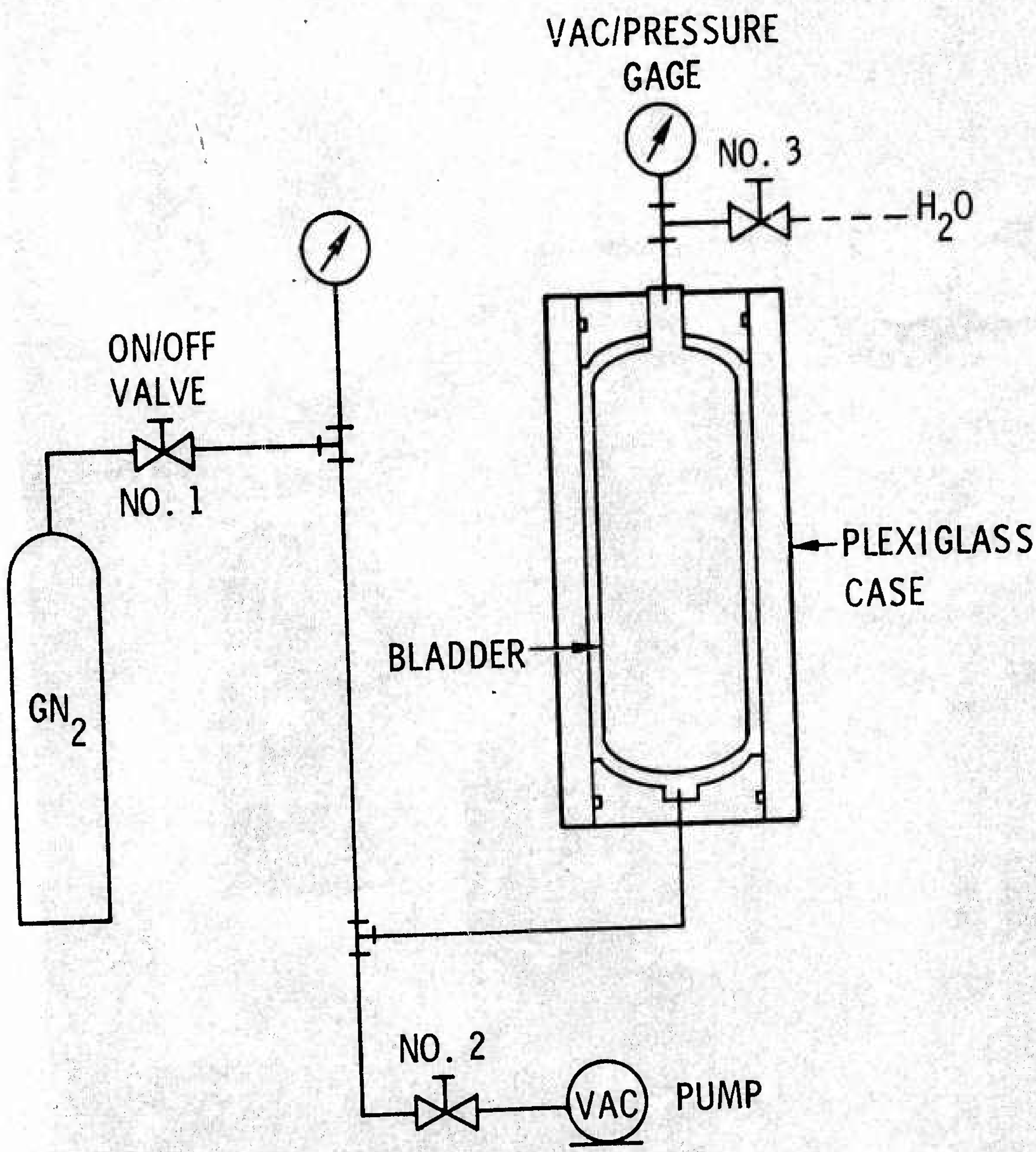


FIG. 6-4. Bladder Expulsion Test (Vertical).

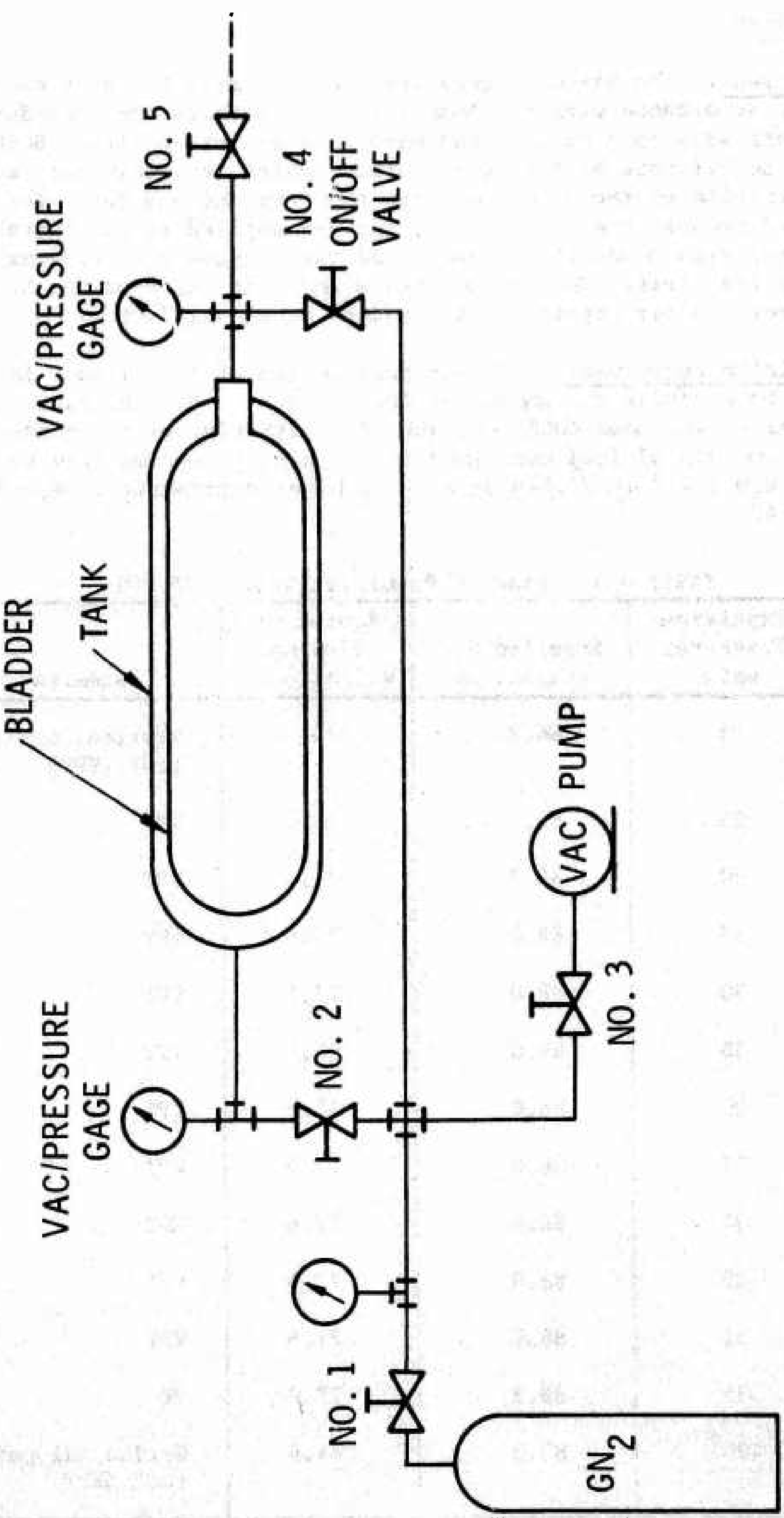


FIG. 6-5. Bladder Expulsion Test (Horizontal).

Test Results

Leak Test. The bladders were leak checked with GN_2 at a minimum of 15 psig in accordance with the leak test and installation procedure. Two bladders were sent back to the manufacturer for repairs. Both bladders had blisters on the outer surface which were only noticeable after evacuation of the volume between the tank and bladder. The blisters were formed because the cosmetic coating was applied to the surface after it was wiped with a volatile cleaner and the trapped volatiles expanded during the leak test. One bladder had a leak; it was repaired by the manufacturer. After repairs, all bladders were satisfactory.

Expulsion Performance. Proper positioning of the bladder is important to maximize the amount of fuel it can hold. The expulsion of fuel contained was near 100%, but due to positioning of the bladder in the tank, amounts of fuel contained in the bladder varied from 85 to 88 pounds of H_2O (74.9 to 77.6 pounds of TH-Dimer equivalent). See Tables 6-3 and 6-4.

TABLE 6-3. Bladder Expulsion Test, S/N 001.

Cycle No.	Expulsion Pressure, psig	Expelled H_2O Weight, lb	Equipment TH-Dimer Weight, lb	Remarks
1	25	86.2	76	Vertical position test (VPT)
2	25	86.5	76.2	VPT
3	30	88.0	77.6	VPT
4	35	88.0	77.6	VPT
5	30	88.0	77.6	VPT
6	30	88.0	77.6	VPT
7	30	88.0	77.6	VPT
8	27	88.0	77.6	VPT
9	37	88.0	77.6	VPT
10	35	88.0	77.6	VPT
11	35	88.0	77.6	VPT
12	35	88.2	77.7	VPT
13	400[a]	85.0	74.9	Horizontal position test (HPT)

TABLE 6-4. Bladder Expulsion Test, S/N 004.

Cycle No.	Expulsion Pressure, psig	Expelled H_2O Weight, lb	Equivalent TH-Dimer Weight, lb	Remarks
1	30	88.0	77.6	Vertical test position (VTP); positioned bladder
2	30	87.9	77.5	VPT
3	40	88.0	77.6	VPT
4	39	87.9	77.5	VPT
5	39	88.0	77.6	VPT
6	38	88.0	77.6	VPT; positioned bladder
				Not positioned end-to-end
7	40	86.2	76	VPT
8	40	84.5	74.5	VPT; not positioned; no vacuum pulled prior to filling
9	39	85.5	75.4	VPT; not positioned
10	38	84.8	74.7	VPT; not positioned
11	37	84.6	74.6	VPT; not positioned
12	30	87.6	77.2	HPT; positioned bladder
13	60[a]	84.7	74.7	HPT leaked at 50 psig; water trapped between tank and bladder[b]

[a] Expulsion test conducted with ground test fuel tank.

[b] Upon examination of the bladder, a metal chip was found which had punctured the bladder. The tank was recleaned and bladder S/N 001 was tested with success. Bladder S/N 004 was patched and re-leak tested with satisfactory results.

The multiple cycle tests were conducted on the two bladders used for expulsion testing. The maximum theoretical internal capacity of the tank (excluding bladder) was 80.59 pounds of TH-Dimer. Therefore, the internal volumetric efficiency based on Tables 6-3 and 6-4 data was estimated at 96.3% with no ullage. Ullage requirements for the vehicle mission have not been specified.

During the first test in the ground test unit, the bladder was damaged by a metal chip, causing a leak. The bladder was patched and tested again with satisfactory results.

Expulsion Life Cycle. Two bladders were expelled a total of 18 times each with no apparent deleterious effects. Life expectancy with cold gas should be at least 25 cycles.

Bladder Expulsion Pressure Logs. No measurable pressure drop was observed during expulsion testing. A 3- to 5-psi drop was measured between GN_2 inlet pressure and fuel outlet line pressure; however, this loss was primarily caused by the 1/4-inch discharge line.

TANK TESTS

The fuel tank and collector pipe were subjected to structural testing and successfully achieved test objectives and satisfied requirements. The ground test tank and collector pipe were used in the bladder expulsion test and the fuel expulsion efficiency test. The collector pipe and bladder, as assembled in the tank, are shown in Fig. 6-6.

Proof Pressure Test

The fuel tank was tested to the requirements of hydrostatic test assembly D/N C11223 and Operations and Quality Record Procedure 1002 (Appendix D). See Fig. 6-7 for the hydrotest schematic. The tank was filled with water and water soluble oil and pressurized with GN_2.

The collector pipe was tested to the requirements of hydrostatic test assembly C11222 and Operations and Quality Record Procedure 1003 (Appendix D). See Fig. 6-8 for the hydrotest schematic. The collector pipe was filled with water and water soluble oil and pressurized with GN_2.

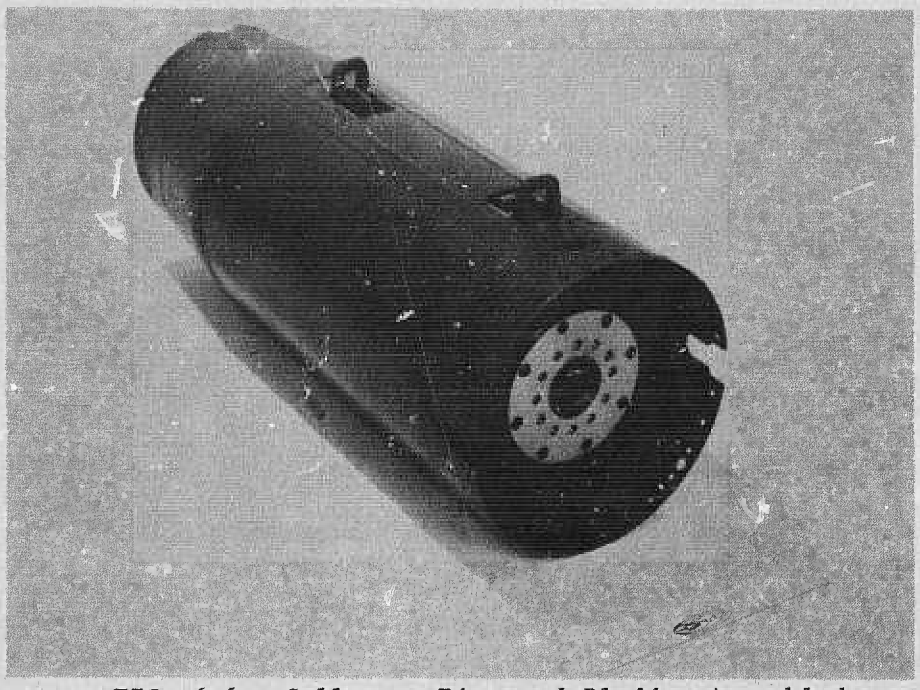


FIG. 6-6. Collector Pipe and Bladder Assembled in Ground Test Tank.

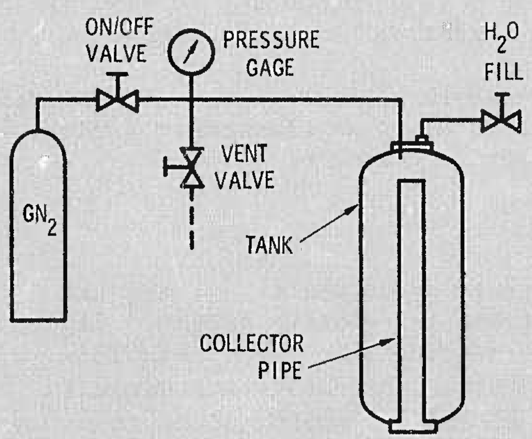


FIG. 6-7. Fuel Tank Test.

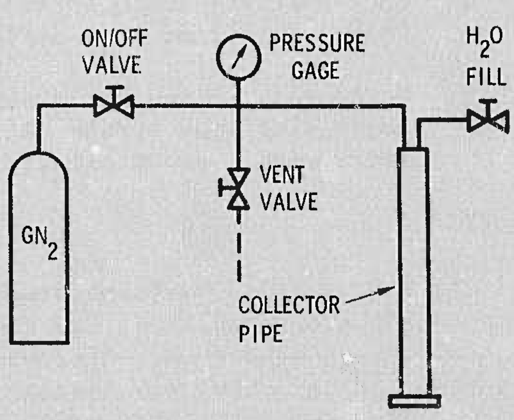


FIG. 6-8. Collector Pipe Test.

7
GORJE FUEL TANK SUSPENSION LUG STRUCTURE TEST

SCOPE

The test report covers testing of the proposed GORJE tank suspension lug and shaft to the ultimate load conditions for captive flight.

OBJECTIVE

The objective of the test was to verify the structural adequacy of the proposed design.

PROCEDURE

Two test units were fabricated as follows:

The suspension lug was machined from a standard 1,000-pound store lug forging (P/N 1252628).

The machined lug was heat treated to 180,000 psi minimum ultimate tensile strength.

The shaft was fabricated from 4340 steel per MIL-S-5000 and heat treated to 180,000 psi minimum ultimate tensile strength.

A test fixture was fabricated from 140,000 psi minimum ultimate tensile strength material. The test fixture was designed to simulate the side wall configuration of the GORJE tank longeron in the area of the lug recess.

All components used are shown in Fig. 7-1. The assembled test unit is shown in Fig. 7-2. The unit was tested in CSD's Tinius-Olsen 300,000-pound tensile test fixture (Fig. 7-3) as follows:

1. Each unit was taken to limit load (11,000 pounds) for two cycles. Load was relaxed to a no-load condition between cycles.

2. Units were subsequently subjected to ultimate load (16,500 pounds) monitoring load versus deflection using an electronic deflectometer with readout printed by an XY recorder.

RESULTS

The test results confirmed the structural capability of the two units to withstand ultimate load conditions for captive flight. Figure 7-4 shows the load versus deflection curves for both units. (NOTE: Deflection is for total test setup; therefore, no deflection scale is shown on Fig. 7-4.) Visual examination of all components after test confirmed that no permanent deformation occurred.

FIG. 7-1. Test Components.

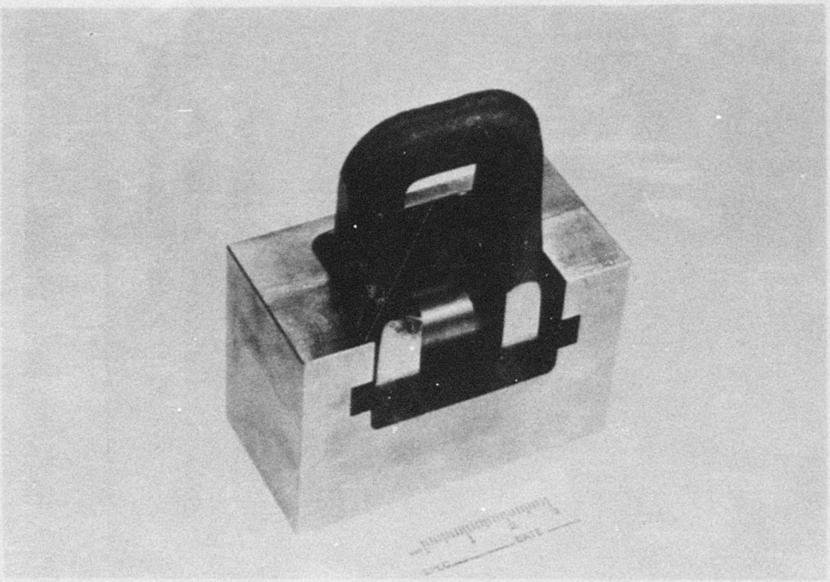


FIG. 7-2. Test Unit.

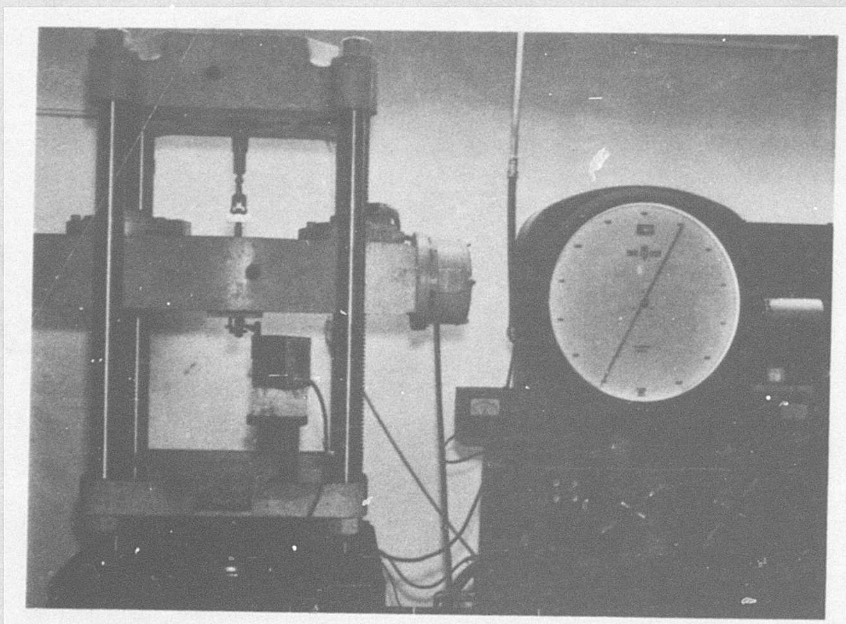


FIG. 7-3. Tinius Olsen Tensile Test Fixture.

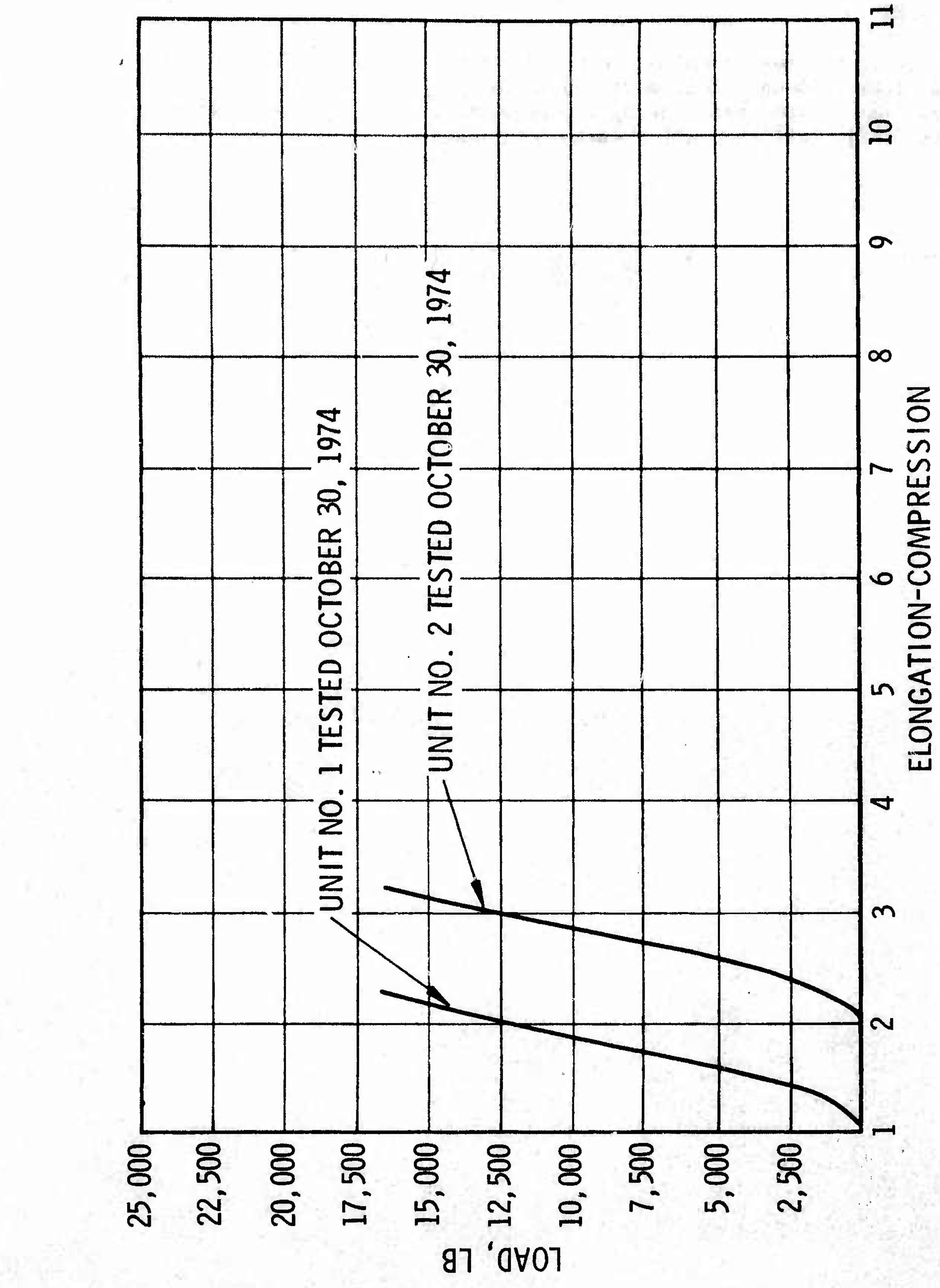


FIG. 7-4. Load Versus Deflection Curve.

CONCLUSIONS

Based on the test results of the two units which had been randomly selected from a 20-unit lot, machined to the proposed design configuration and heat treated per drawing requirement, it is concluded that the proposed design will meet all program requirements.

Appendix A

GORJE FUEL TANK ASSEMBLY DATA PACKAGE

GORJE FUEL MANAGEMENT SYSTEM

Baseline Design

See Fig. A-1.

Theory of Operation

Pressurization Subsystem. The pressurization subsystem is a nozzleless cool gas generator housed in the centrally mounted collector pipe assembly. The gas exhausts through holes in the collector pipe assembly mounting boss at the forward end of the fuel tank. Pressure is regulated by a relief valve.

Expulsion Device. The expulsion device is nominally an elastomeric bladder attached to the collector pipe assembly at the tank ends. Gases from the gas generator collapse the bladder forcing fuel through holes in the collector pipe and down the annular gap between the collector pipe and gas generator housing to the fuel controller.

Fuel Controller. The fuel controller is an altitude scheduled, bellows activated, cavitating venturi valve. Fuel from the collector pipe enters the fuel controller through radial holes and exits through the aft tank closure to a normally closed explosive valve. As the fuel controller is normally open, the tank is filled back through the fuel controller. A fill vent is also provided in the fuel controller.

GORJE FUEL TANK ASSEMBLY BASELINE DESIGN AND REQUIREMENTS

Fuel Tank

See Fig. A-2. Structural design criteria are shown on Fig. A-3.

Collector Pipe

See Fig. A-4.

Bladder

Requirements.

1. The bladder will be compatible with the following environment at a pressure of 450 psig and a temperature of 550°F:

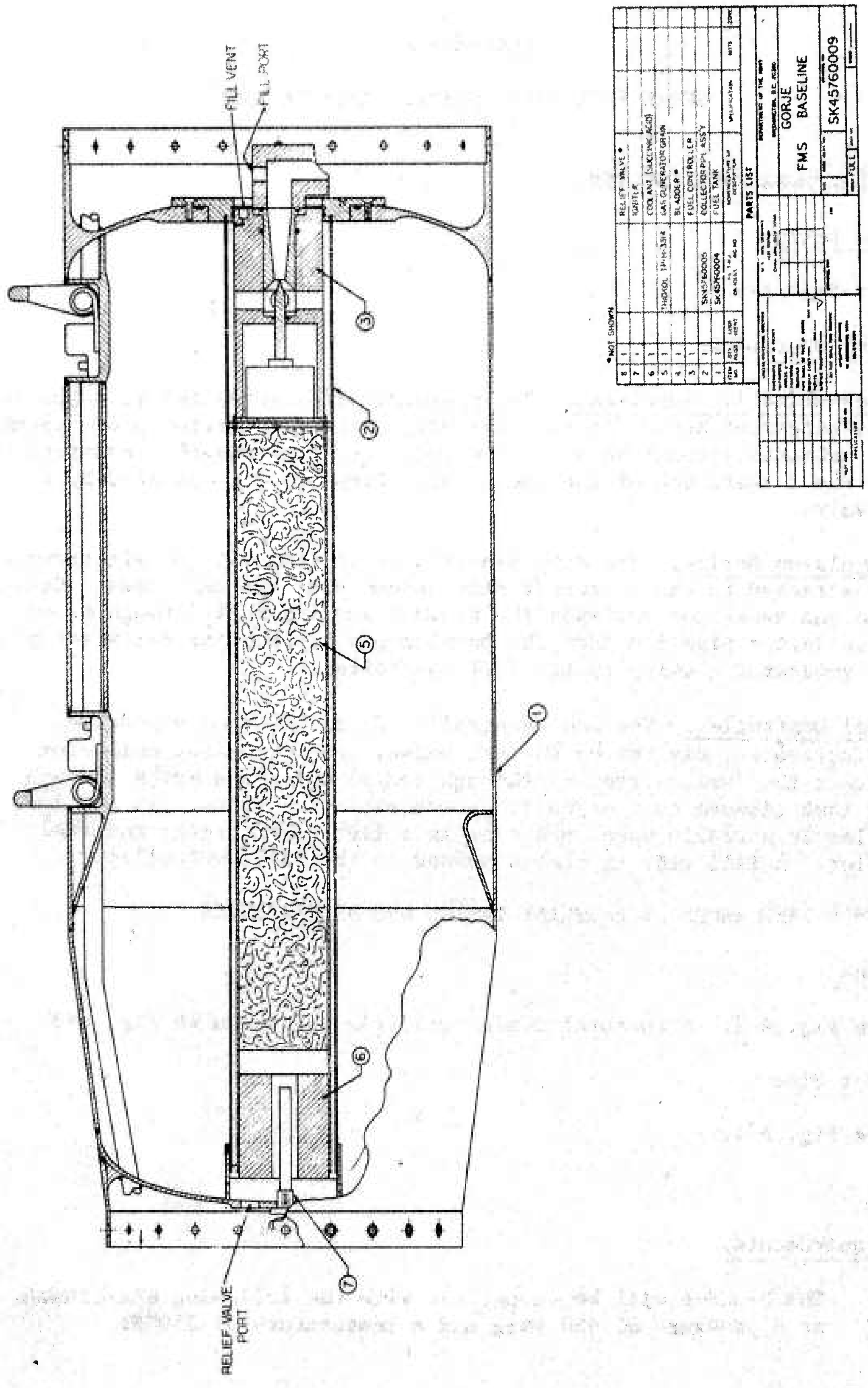


FIG. A-1. GORJE FMS Baseline.

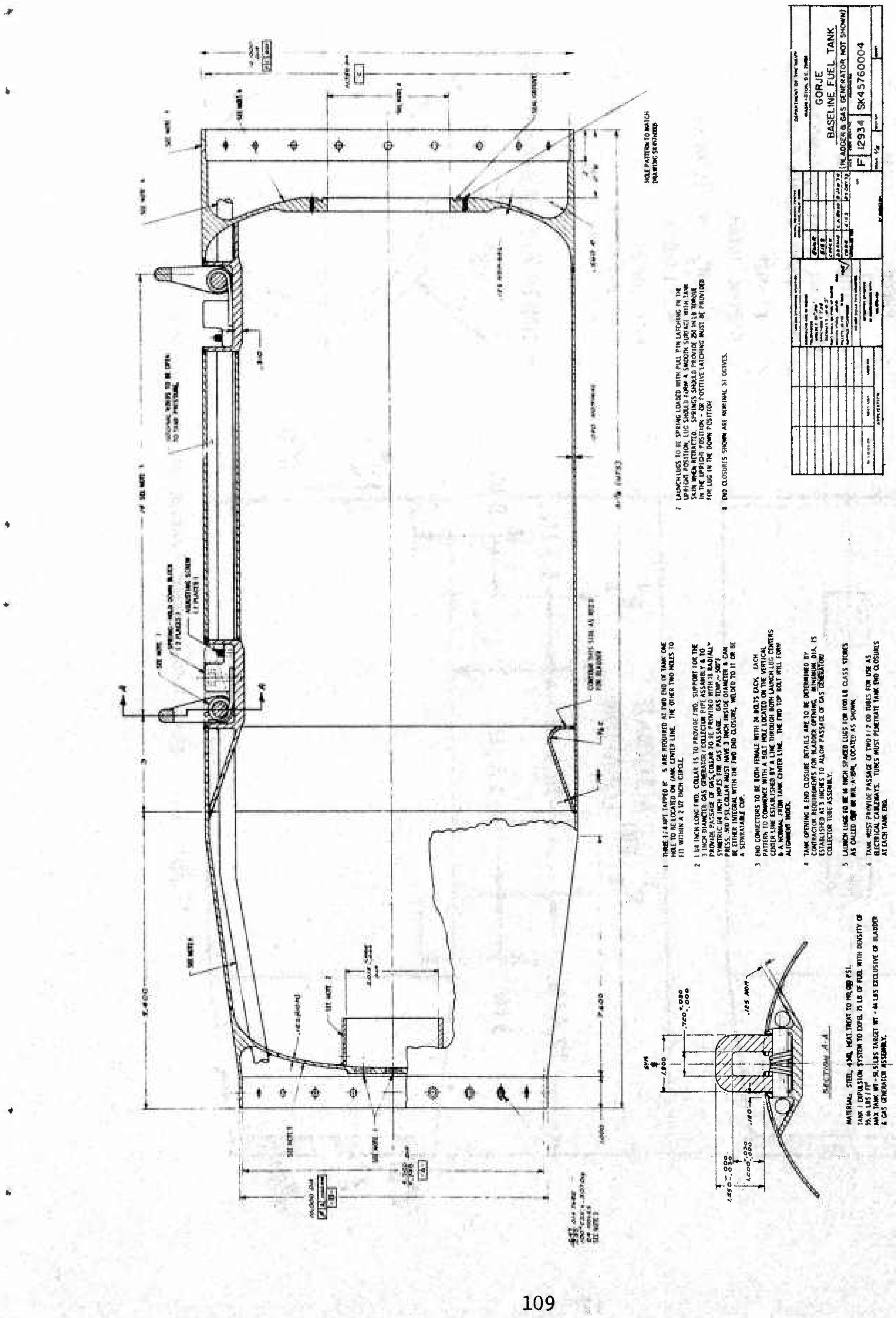
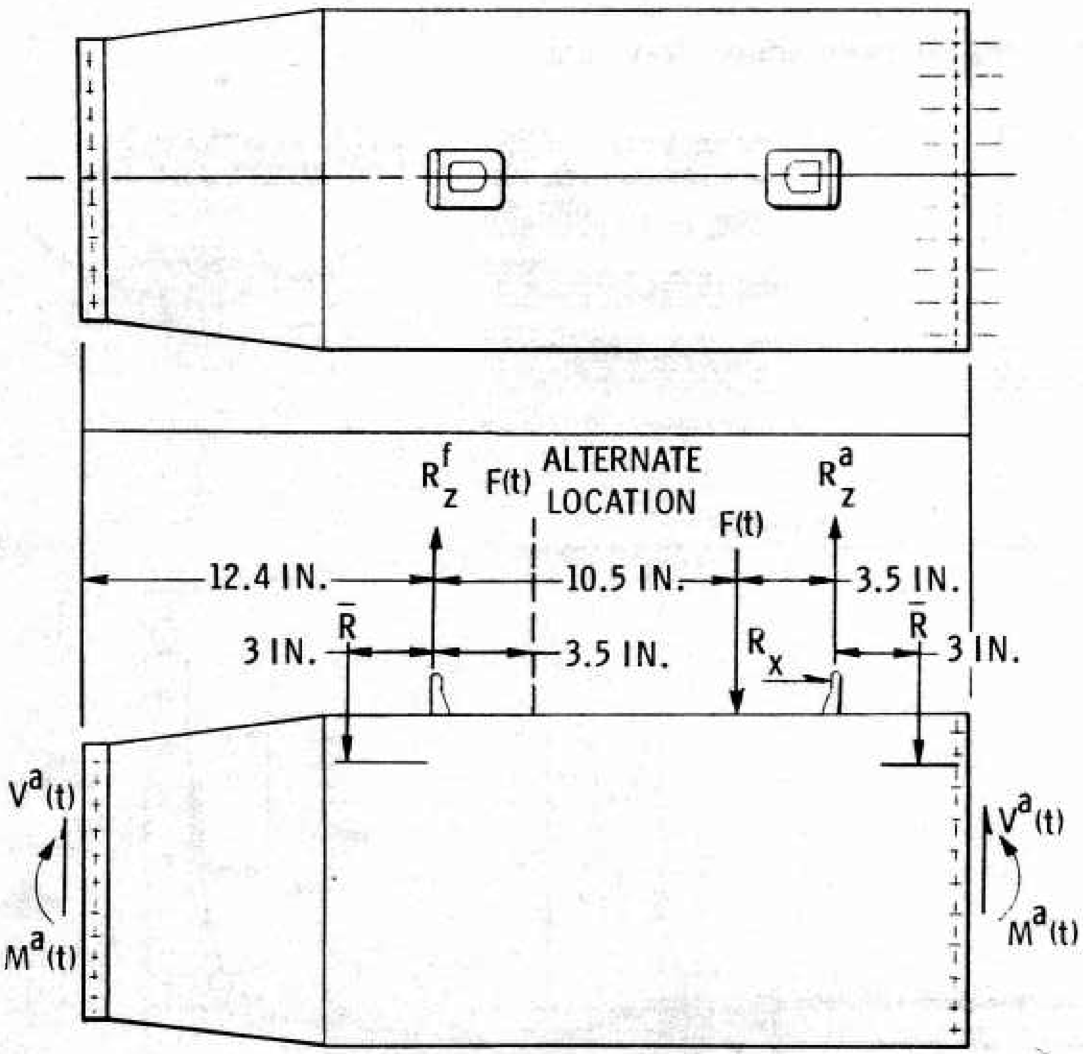


FIG. A-2. GORJE Baseline Fuel Tank.



DESIGN FACTORS – ALL POINT LOADS
YIELD = 1.15 ULTIMATE = 1.5

PRESSURE LOADS – TANK, PSI

PROOF	450
YIELD	475
ULTIMATE	550

LOADS (ALL LOADS INDEPENDENT)
FREE FLIGHT INTERNAL TEMPERATURE

$T = 550^{0}F$

CAPTIVE FLIGHT

$R_z^f = R_z^a = -\bar{R} = 11{,}000$ LB

$R_x = 1{,}000$ LB

EJECT LOADS

$F(t) = 10{,}000$ LB
$M(t) = 110{,}000$ IN -LB $\quad \mathrm{SIN}\left[\left(\frac{\pi}{60}\right)^{**} t\right]$

** UNITS ARE RADIANS/MSEC

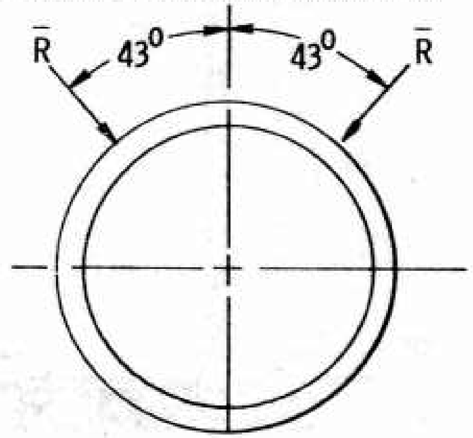


FIG. A-3. Fuel Management System Structural Criteria.

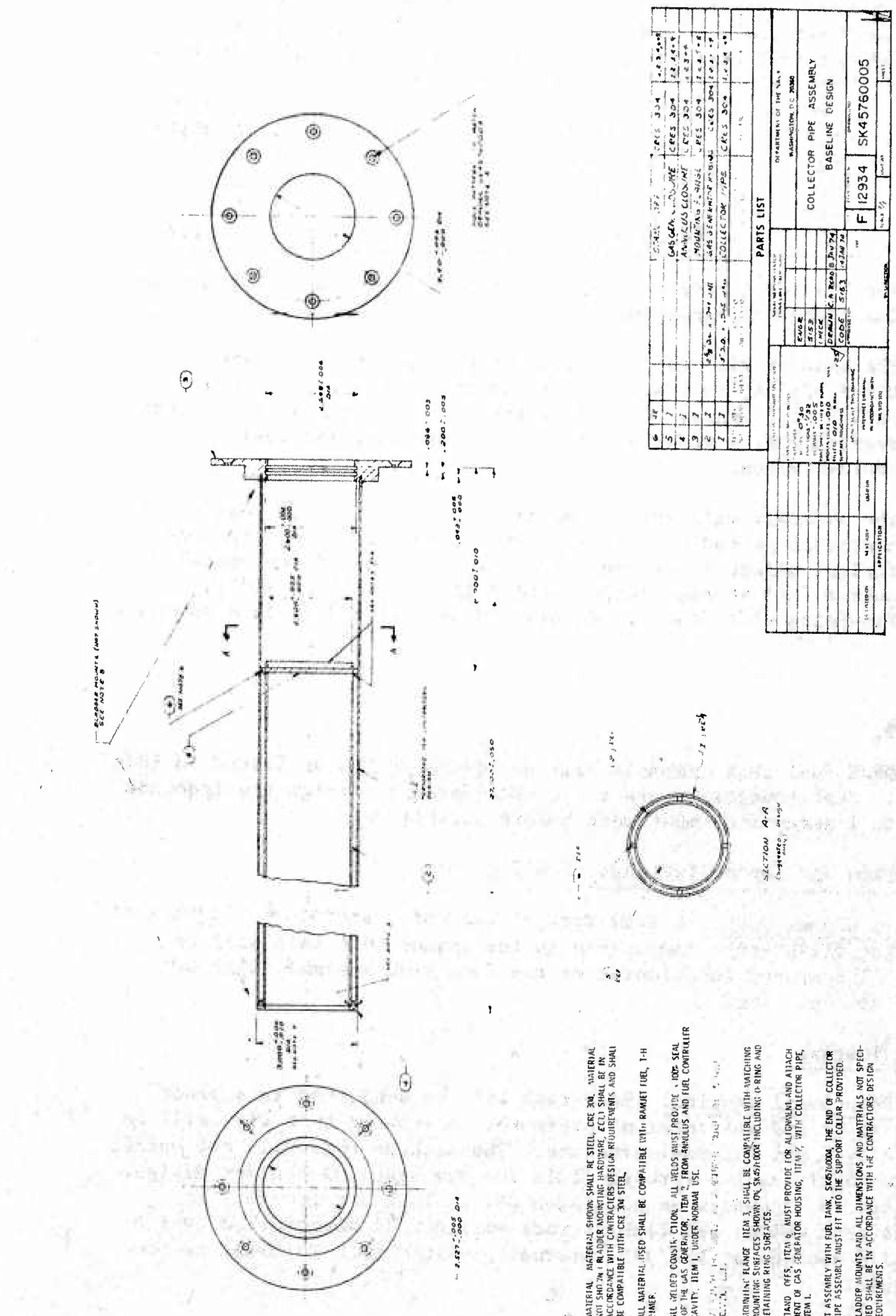


FIG. A-4. Collector Pipe Assembly Baseline Design.

Gas Generator Exhaust Products	Mole Fraction	Gas Generator Exhaust Products	Mole Fraction
FeO	0.00020	C	0.06364
H_2O	0.11542	N_2	0.06140
H_2	0.30088	$FeCl_2$	0.00040
CO	0.21137	CH_4	0.03306
CO_2	0.11358	COS	0.00023
HCl	0.07883	H_2S	0.02094

The bladder functions properly in this environment for 120 sec (maximum fuel expulsion cycle).

2. The bladder will be compatible with ramjet fuel TH Dimer, MIL-F-82522A, to ensure proper functioning after a storage period of 5 years. Compatibility includes minimal structural degradation, bladder swell, fuel permeation, and fuel contamination.

3. The assembly will expel a minimum of 1.3475 ft^3 of fuel after a storage period of 5 years. The bladder will contain sufficient ullage to prevent structural failure of the assembly over a fuel storage temperature range of -40°F to 140°F. Expulsion efficiency is determined as outlined in this appendix.

TESTING

NWC Testing

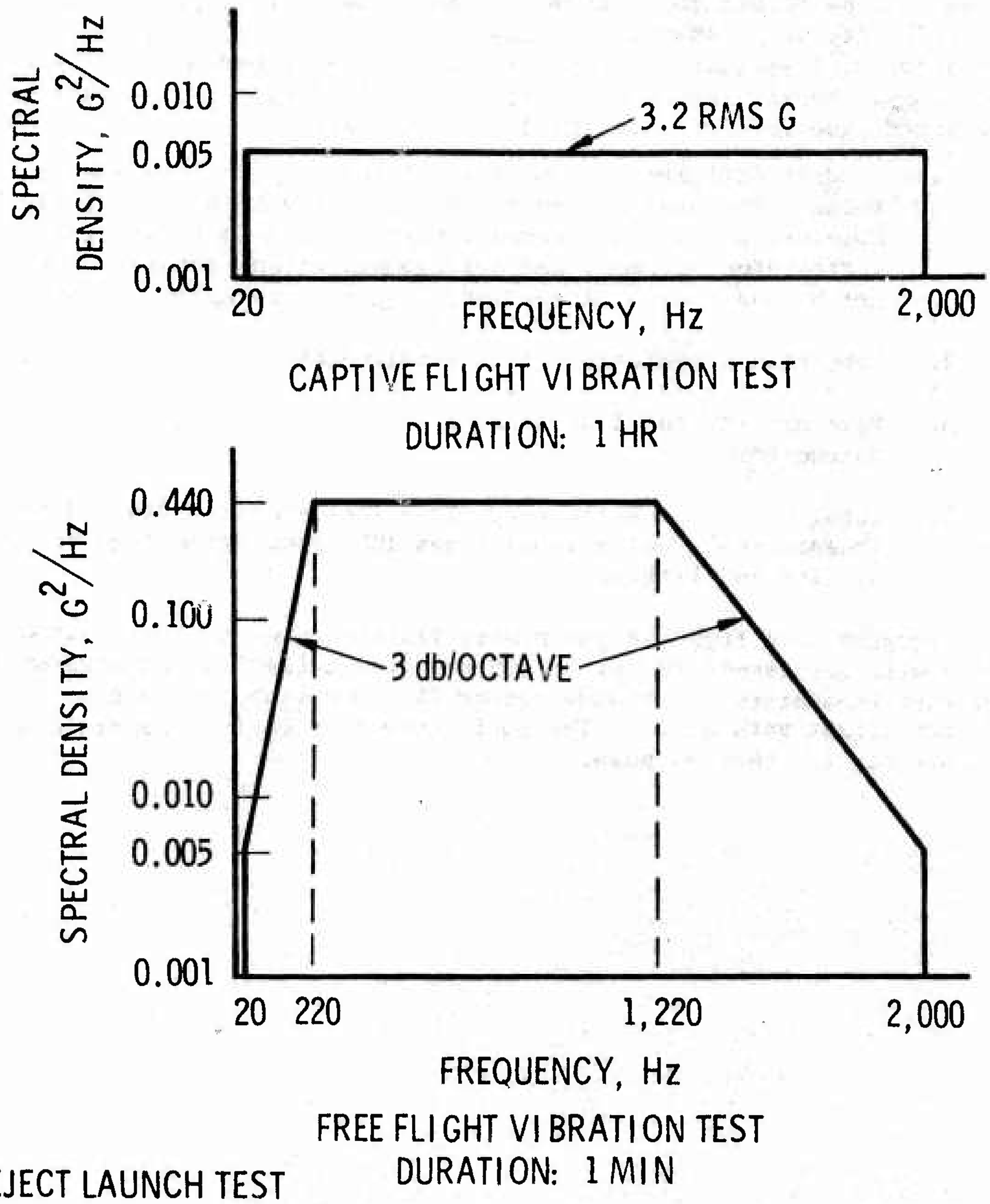
The GORJE fuel tank assembly will be tested at NWC as listed in this subsection. Test conditions are to be considered as design requirements which the full assemblies must meet before acceptance.

Vibration and Impact Testing. See Fig. A-5.

Vehicle Ground Test. A semi-freejet test of a prototype flight test vehicle using flight-type components in the ground test unit will be conducted. The proper functioning of the fuel tank assembly will be determined at that time.

Contractor Testing

Tank Structural Testing. Each tank will be subjected to a proof pressure test at 450 psi internal pressure. A leakage test also will be conducted at 450 psi internal pressure. The leakage rate will not exceed 2 psi/min with air as the working fluid for the baseline bladder design. If the contractor proposes an expulsion device that permits fuel to contact the tank walls, the leakage rate will not be discernible over a period of 120 seconds at 450 psi internal pressure with TH Dimer as the working fluid.



NOTE: EJECT LAUNCH TEST

PULSE: $F(t) = (10{,}000\ \mathrm{LB})\ \mathrm{SIN}\left[\left(\frac{\pi}{60}\right) t\right]$

t IN MSEC

$0 \leq t \leq 60$ MSEC

FIG. A-5. Captive and Free Flight Vibration Tests.

Expulsion Testing. NWC will supply the contractor with a flight-type fuel controller for use in the expulsion testing. The bladder design will be tested to confirm structural integrity, proper functioning, and cycle life at pressurization gas conditions of 450 psi, 550°F. The contractor will estimate the cycle life of the bladder under flight conditions. Total expulsion efficiency of the flight design will be determined experimentally on the following basis:

1. Loading Efficiency - theoretical fuel volume less inerts and voids. The bladder and bladder mounts will be considered inerts. However, the volume occupied within the 3-inch-diameter collector pipe assembly and corresponding tank mounting cup will not be considered as theoretically available fuel volume.

2. Expulsion Efficiency - fuel expelled divided by fuel loaded.

3. Permeability and leakage loss for 5 year storage - need only be documented.

4. Total Expulsion Efficiency (%) - fuel expelled divided by (theoretical fuel volume) times 100 minus percentage of permeability and leakage.

Pressure loss from the gas pressurization inlet to fuel controller cavity will not exceed 40 psi at 400 psi pressurization and maximum fuel flow rate (nominally 3.2 pounds/second TH Dimer with the tank at a 0-degree flight path angle. The fuel controller will incorporate a pressure tap for this purpose.

Appendix B

GORJE FUEL TANK DRAWING LIST

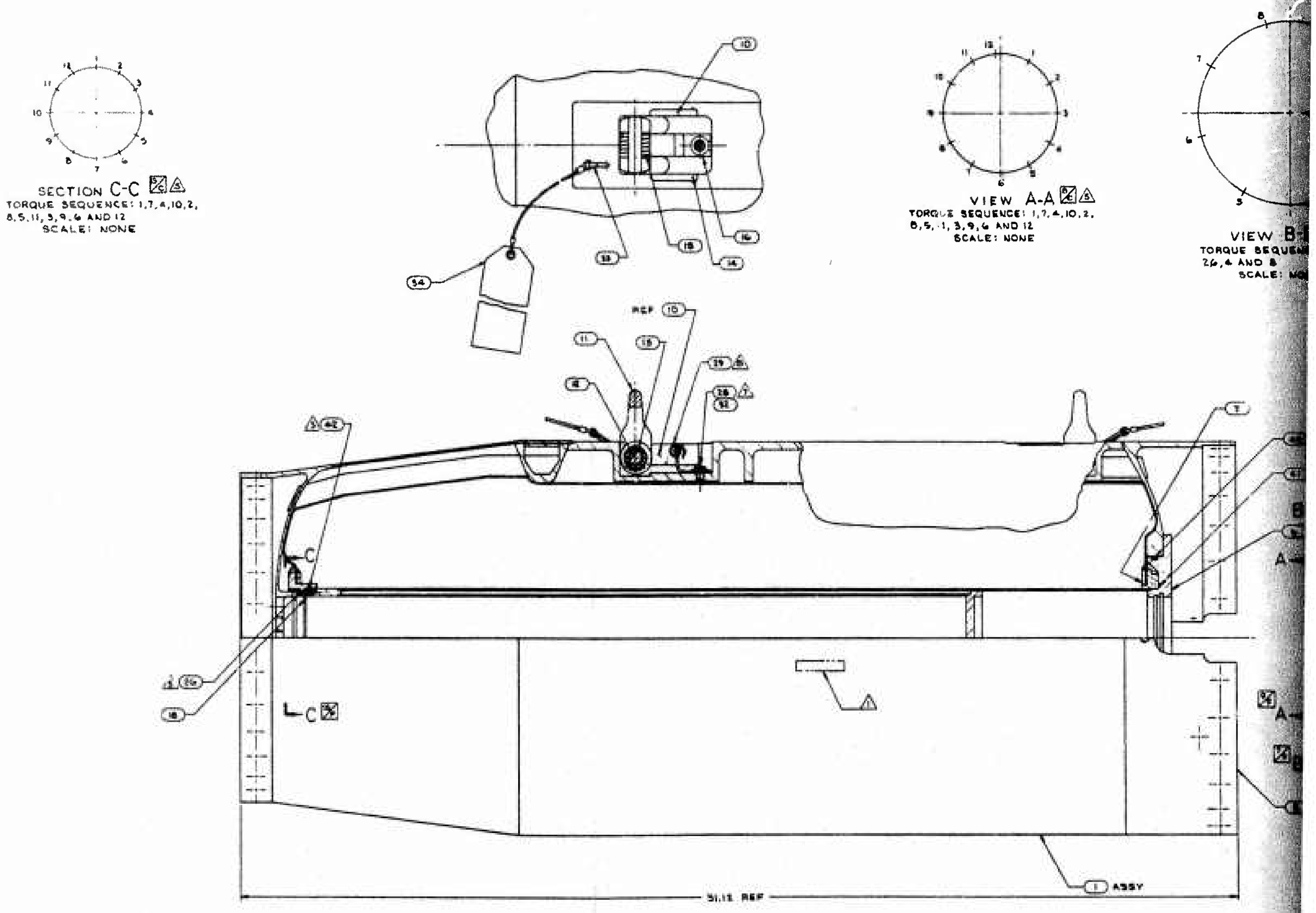
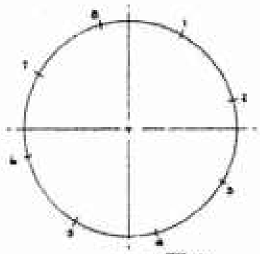


FIG. B-1. Fuel Tank Assembly, GORJE.

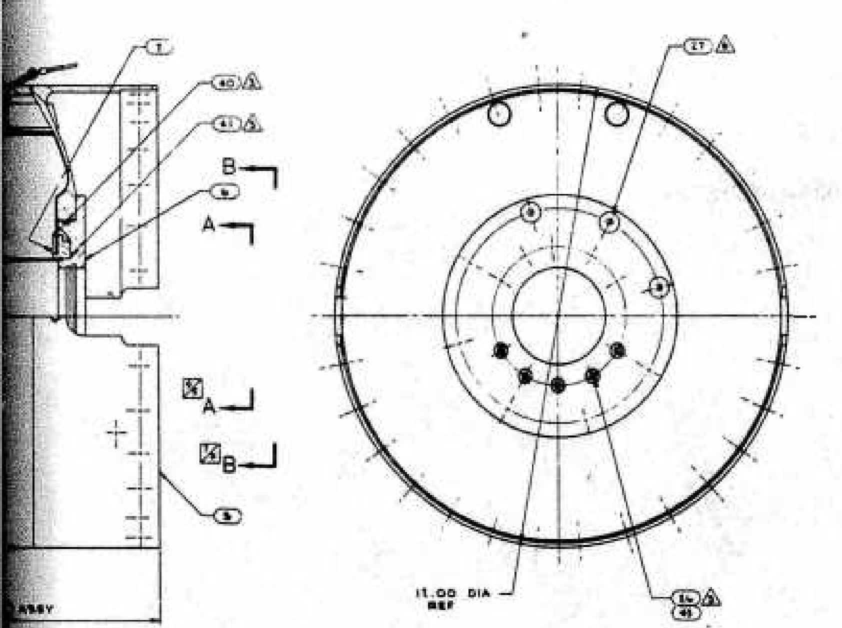


VIEW B-B

TORQUE SEQUENCE: 1, 5, 3, 7, 2, 6, 4 AND 8
SCALE: NONE

NOTES:
1. RUBBER STAMP PART NO. & SERIAL NO. WITH 1/4 INCH HIGH CHAR IN APPROX LOCATION SHOWN.
2. APPLY A THIN COATING OF ITEM 51 TO BOLTS, (UNDER HEAD, SHANK AND THREADS) THREADED HOLES, AND FACES OF WASHERS. PRIOR TO LUBRICATING, CLEAN THREADS TO REMOVE FOREIGN PARTICLES.
3. INSPECT AND CLEAN O-RINGS, O-RING GROOVES AND SEALING SURFACES WITH A LINT-FREE CLOTH. LUBRICATE WITH A THIN COATING OF ITEM 50.
4. PARKER SEAL CO., O-SEAL DIV OF PARKER HANNIFIN CORP., CULVER CITY, CALIF. (OR APPROVED EQUIV.)
5. TORQUE ITEM 26 TO 10-12 IN. LBS PER SEQUENCES SHOWN IN VIEW A-A AND SECTION C-C.
6. TORQUE ITEM 27 TO 100-120 IN LB. PER SEQUENCE SHOWN IN VIEW B-B.
7. TORQUE ITEM 28 TO 45-55 IN. LB.
8. TORQUE ITEM 29 TO 15-20 IN. LB.
9. ITEM 27 SHALL HAVE A MINIMUM OF 160,000 ULTIMATE TENSILE STRENGTH.
10. ITEMS 6, 7, 34 AND RELATED HARDWARE MAY BE SHIPPED IN THE UNASSEMBLED STATE AND ASSEMBLED AFTER SHIPMENT PER THE REQUIREMENTS OF THIS DRAWING.

	A	1. IN P/N BLOCK, PART NO. IS: -01-02 C11225-01-02 WAS: -01-01 C11225-01-01		
		2. IN L/M, ITEM 1, IS: -01-02 WAS: -01-01		
		3. IN L/M, ITEM 5, IS: C11224 -01-02 WAS: C11224 -01-01		
		4. IN L/M, ITEM 16, IS: C11216 -01-02 WAS: C11216 -01-01		
		5. IN G/N, NOTE 1, IS: RUBBER ... PART NO. & SERIAL NO WITH ... CHAR IN APPROX ... WAS: RUBBER ... PART NO. WITH ... CHARACTERS IN APPROX ...		
		6. IN L/M, QTY OF ITEMS 28 & [illegible] IS: 2 WAS: 4		
11/E		7. ON F/D, REVISED PICTURE		
11/G		TO SHOW DESIGN CHANGES		
		8. IN G/N, ADDED NOTE 10.		



	QTY	CODE IDENT	PART OR IDENTIFYING NO.	DESCRIPTION	ZONE	ITEM NO.
						56
						55
						54
						53
						52
2	AR		—	THREAD COMPOUND PER MIL-T-5544		51
3	AR		—	GREASE PER MIL-G-4343		50
						49
						48
						47
						46
						45
						44
4	12	83259	800-530 -2	LOCK-O-SEAL	7/A	43
4	1	83259	2-151 N674-70	O-RING (BUNA N)	13/E	42
4	1	83259	2-042 N674-70	O-RING (BUNA N)	8/D	41
4	1	83259	2-248 N674-70	O-RING (BUNA N)	6/E	40
						39
						38
						37

	QTY	CODE IDENT	PART OR IDENTIFYING NO.	DESCRIPTION	ZONE	ITEM NO.
						36
						35
10	2		NAS1091 A36H	STREAMER ASSY	13/F	34
	2		AN380-4-6	PIN, COTTER	11/F	33
	2		MS27183-8	WASHER, FLAT, ROUND, STL	11/E	32
						31
						30
	4		—	SCREW, CAP, BUTTON HD, STL, BLK OXIDE, [illegible]	[illegible]	29
	2		—	SCREW, CAP, BUTTON HD, STL, BLK OXIDE, [illegible]	[illegible]	28
6	8		—	SCREW, CAP, SOCKET HD, STL, [illegible]	[illegible]	27
	24		—	SCREW, CAP, SOCKET HD, STL, BLK OXIDE, 4-40UNC-3A×.38 LG	7/A	26
						25
						24
						23
						22
						21
						20
						19
	1		C11219 -01-01	RING, RETAINER	14/E	18
						17
	2		C11216 -01-02	SPRING, FLAT	11/F	16
	2		C11215 -01-01	SPRING, HELICAL, TORSION	11/F	15
	2		C11206 -01-01	RETAINER, LUG	11/F	14
	2		C11217 -01-01	SLEEVE	11/E	13
	2		C11218 -01-01	SHAFT	12/E	12
	2		C11207 -01-01	LUG, SUSPENSION	12/F	11
	2		C11208 -01-01	RETAINER, LUG	11/G	10
						9
						8
10	1		C11145 -01-01	BLADDER ASSY	[illegible]	7
10	1		C11210 -01-01	COLLECTOR PIPE ASSY	[illegible]	6
	1		C11224 -01-02	TANK, FUEL	[illegible]	5
						4
						3
						2
			-01-02	ASSEMBLY	[illegible]	1

PARTS LIST

NOO-[illegible]-C-1[illegible]

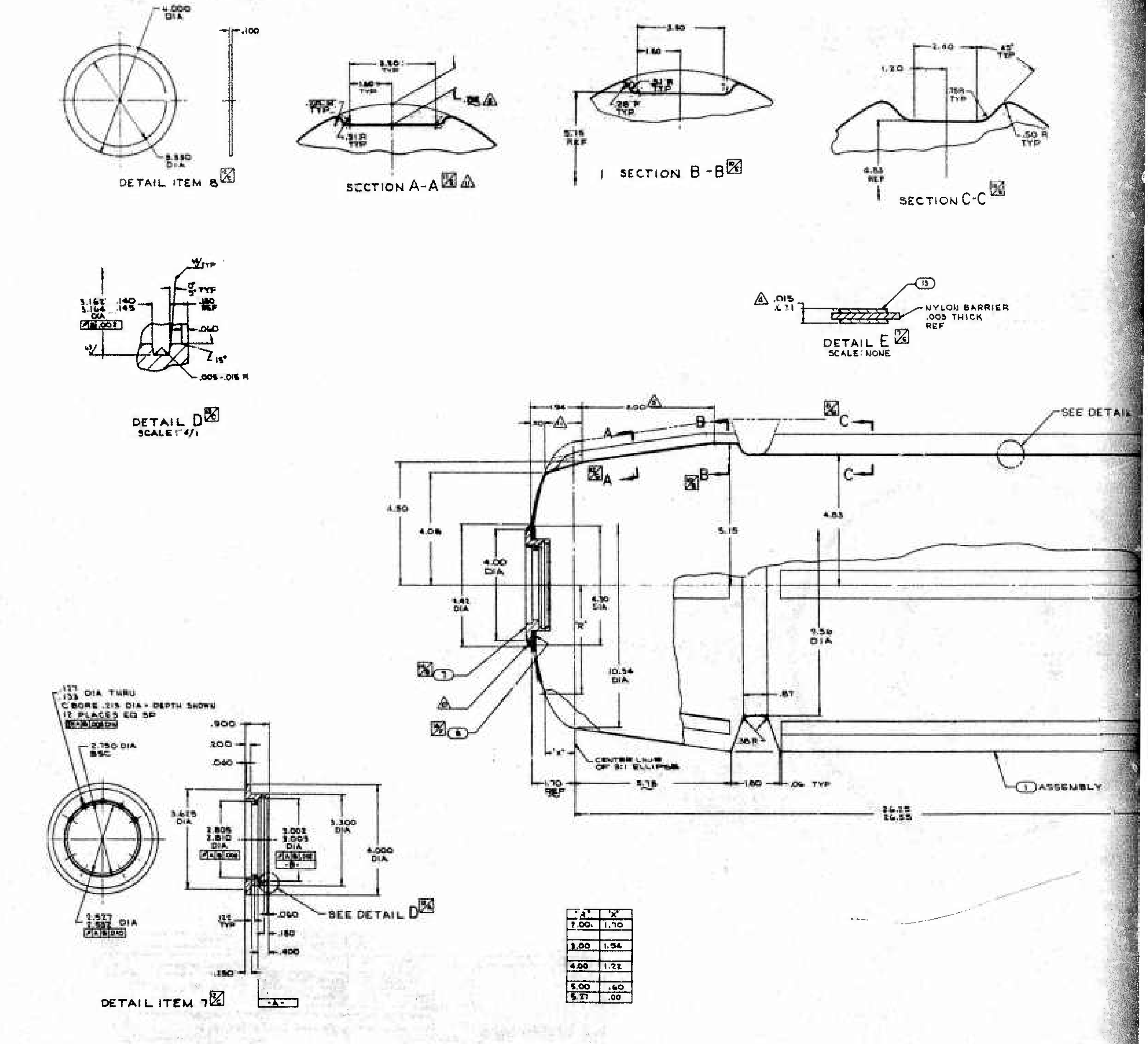
United Technology Center

FUEL TANK ASSEMBLY-
GORJE

J 14134 C11225 A

-01-02 C11225-01-02 FINAL

2



"A"	"X"
7.00	1.70
3.00	1.54
4.00	1.22
5.00	.60
5.27	.00

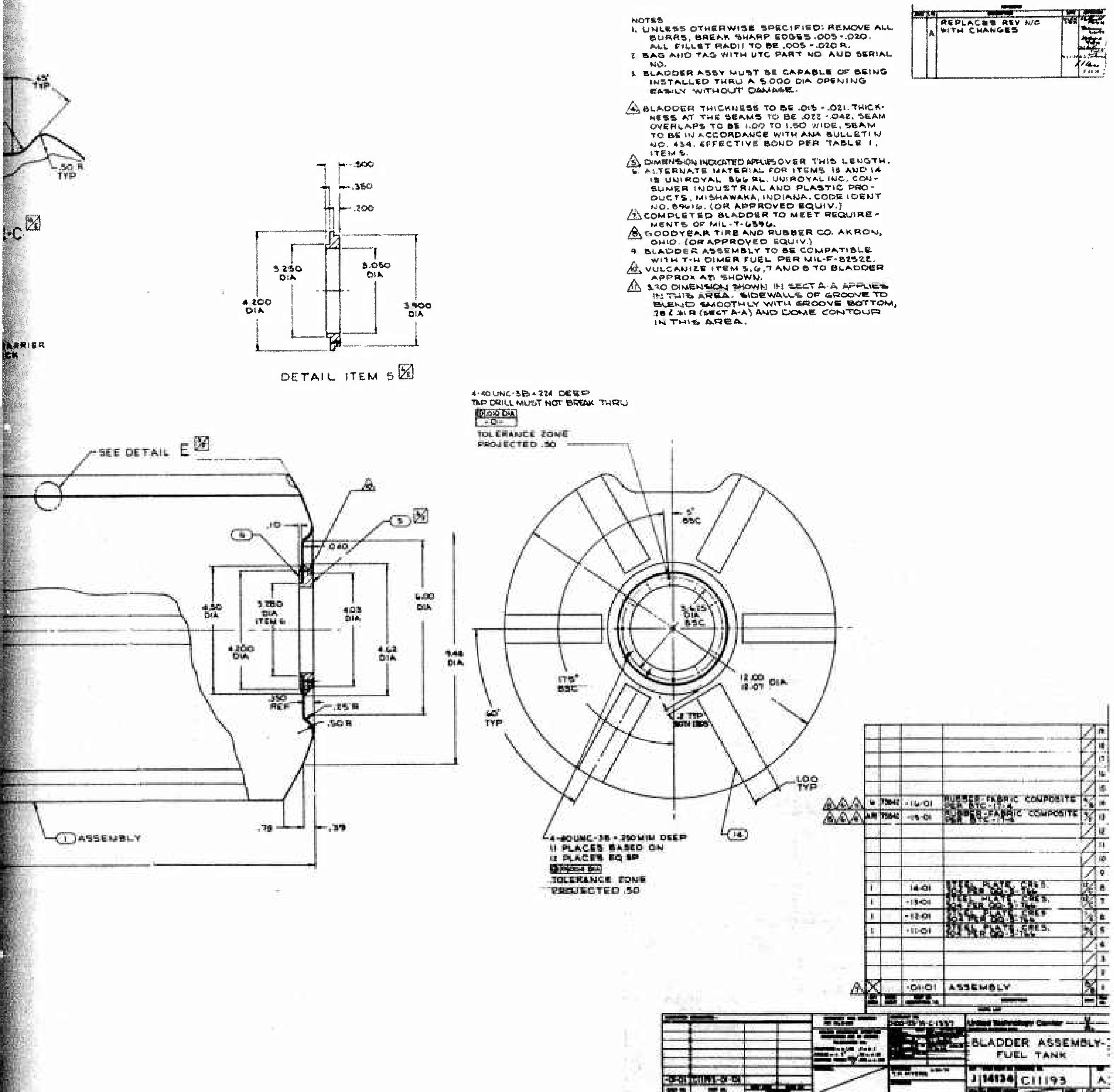


FIG. B-2. Bladder Assembly, Fuel Tank.

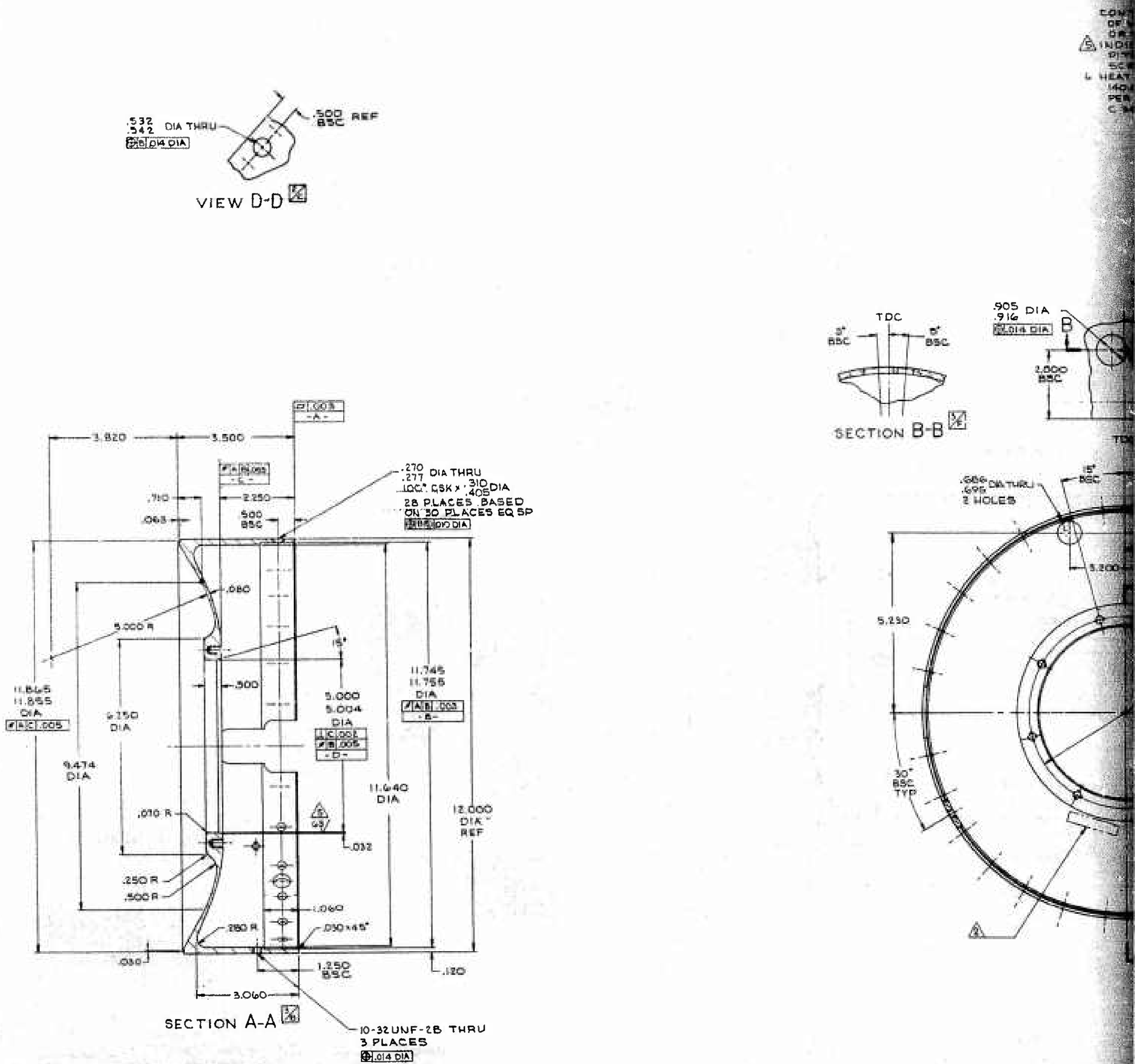
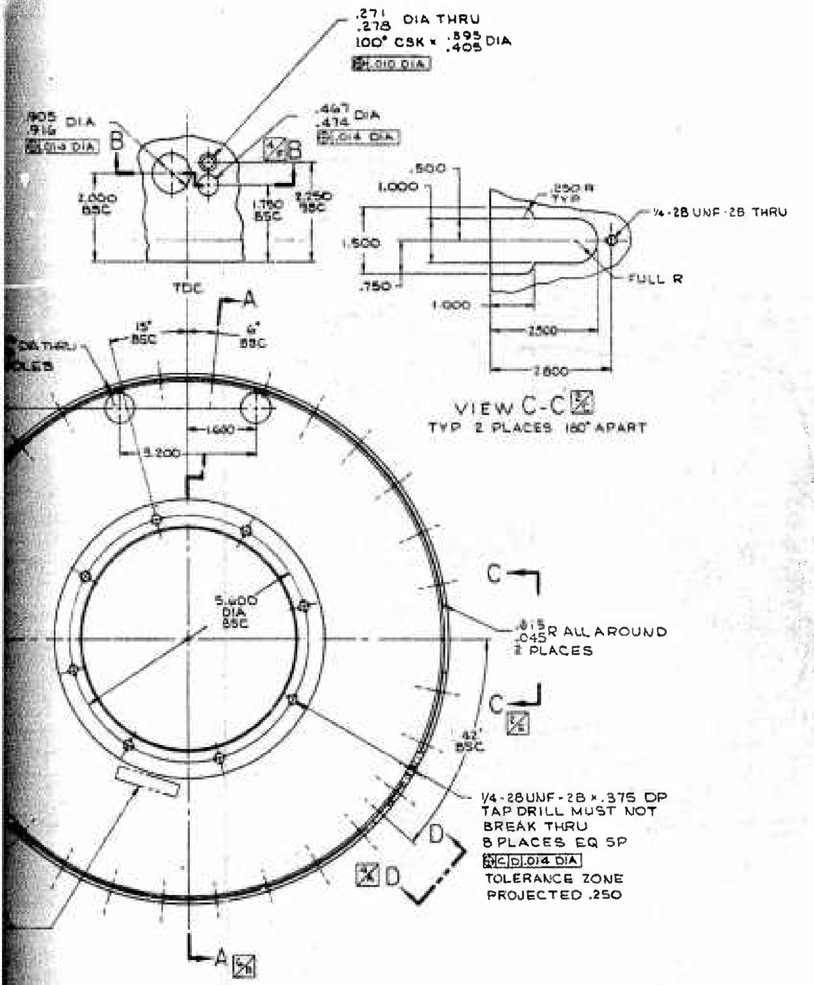


FIG. B-3. Closure, Aft.

NOTES
1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005-.020. ALL FILLET RADII .005-.020 R.
2. RUBBER STAMP PART NO. WITH 1/4 INCH HIGH CHARACTERS IN APPROX. LOCATION SHOWN.
3. DIMENSIONS APPLY IN THE RESTRAINED CONDITION.
4. FLUORESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-I-6868 ALL SURFACE 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA 5.1.2. METHOD

CON'T.
OF MAGNETIZATION OPTIONAL. NO CRACKS OR DISCONTINUITIES ALLOWED.
5. INDICATED SURFACE TO BE FREE OF NICKS, PITS, RUST, TOOL CHATTER MARKS AND SCRATCHES.
6. HEAT TREAT PRIOR TO FINAL MACHINING TO 140,000-150,000 ULTIMATE TENSILE STRENGTH PER MIL-H-6875. HARDNESS TO BE ROCKWELL C 34-39.

LTR	DESCRIPTION
A	15: .045 WAS .150 ADDED: .070 R



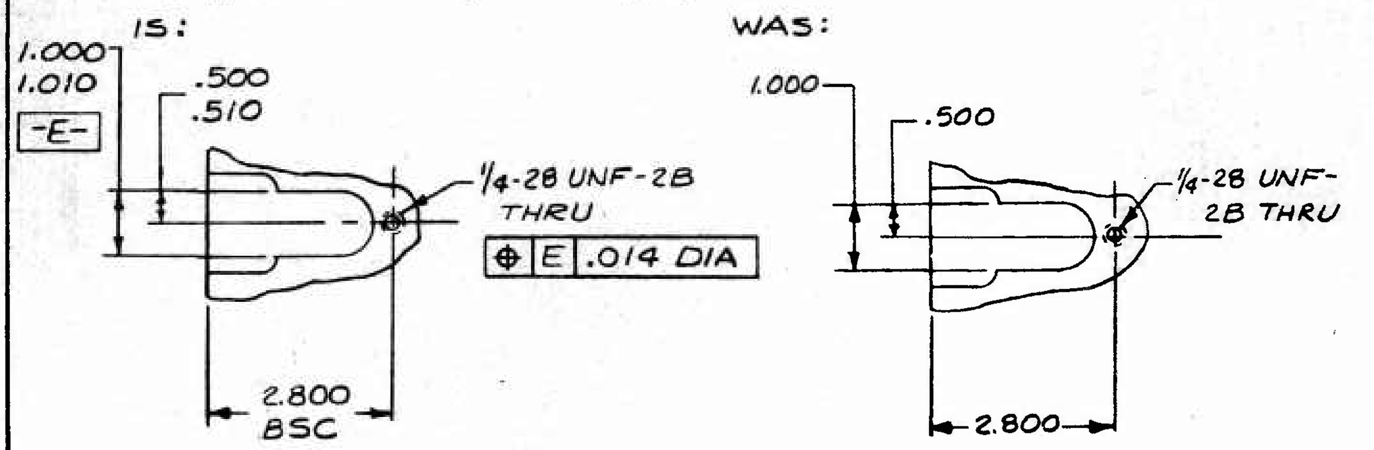
	United Technology Center
	CLOSURE, AFT
MATERIAL	4130 STL PER MIL-S-18729, COND A
PART NO.	-01-01 C11201-01-01 C11134
SIZE / CODE IDENT NO. / DRAWING NO. / REV	E 14134 C11201 A

CLASS ____ CRBD ____ DWR 2623

DRAWING/~~SPECIFICATION~~ NO. C11201 A/1	REV	ENGINEERING CHANGE ORDER United Technology Center	PROJ. NO. 3990	E.C.O. 18876
TITLE CLOSURE, AFT		U A	14134 CODE IDENT NO.	SHEET 1 OF 1
PREPARED Abbott DATE 2-10-75	DESIGN ENGINEER 2-14-75	PROJECT MANAGER / PROJECT ENGINEER / QUALITY CONTROL / CHANGE CONTROL	RELEASE FORM NO. 15870-516-	DATE 2-19-75
CHECKED DATE 2-14-75	ANALYSIS 2-17-75	MATERIALS / SAFETY	APPROVAL	APPROVAL

REVISED DWG AS FOLLOWS:

1. ON F/D, VIEW C-C, ZONE 2/E,



REASON FOR CHANGE DESIGN IMPROVEMENT

DISPOSITION OF MATERIAL

UTC 519 (6/67)

FIG. B-3. (Contd.)

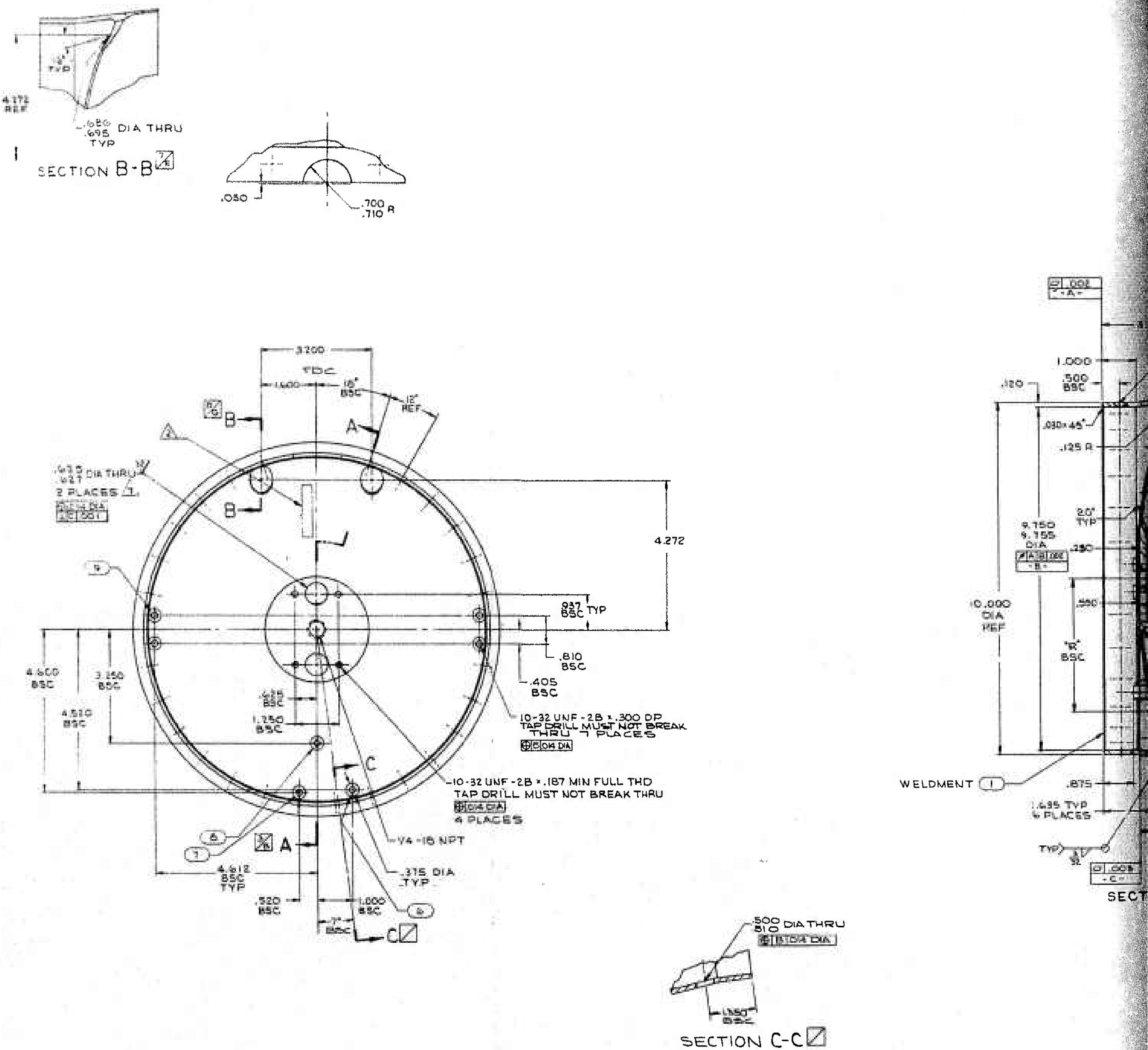
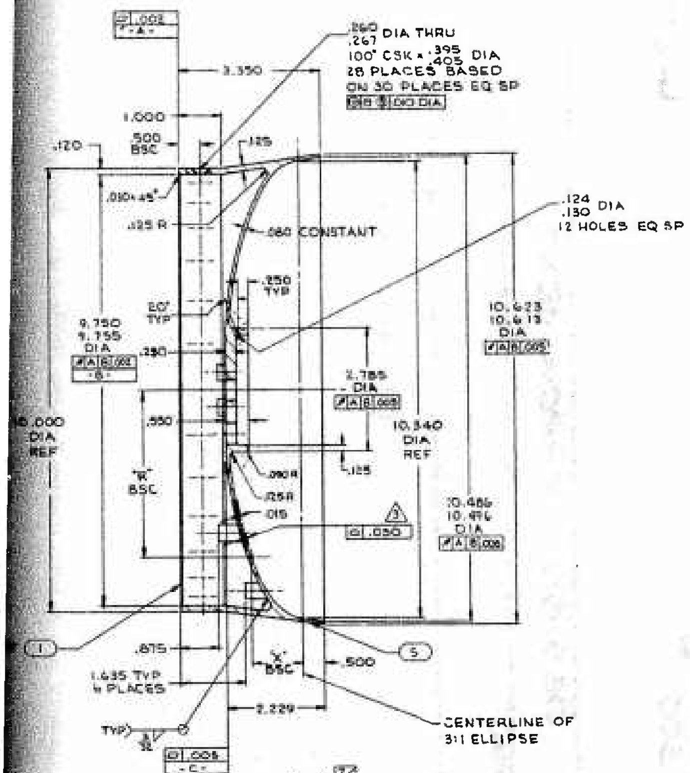


FIG. B-4. Closure, Forward.

NOTES:
1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS; BREAK ALL SHARP EDGES .005-.020; ALL FILLET RADII .005-.020.
2. RUBBER STAMP PART NO. WITH 1/4 HIGH CHARACTERS APPROX AS SHOWN.
3. MAX RATE OF CHANGE FOR THE ENTIRE CONTOUR OF DOME IS .040 INCH/INCH.
4. DIMENSIONS APPLY IN THE RESTRAINED CONDITION.
5. FLUORESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-I-6868, ALL SURFACES 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA. 5.1.2. METHOD OF MAGNETIZATION OPTIONAL. NO CRACKS OR DISCONTINUITIES ALLOWED.
6. WELD PER MIL-W-8611.
7. NO TOOL CHATTER MARKS, PITS, RUST OR SCRATCHES ALLOWED ON INDICATED SURFACES.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
B/6	A	ADDED: ⊥ C .001		
4/6		ADDED: ▱ .005 -C-		
4/6		IS 10-32UNF-2B x .300 DP WAS: 10-32UNF-2B x .375 DP		
3/6		ADDED SECT C-C		



SECTION A-A

"R" BSC	"X" BSC
1.500	1.649
1.750	1.621
2.000	1.589
2.250	1.551
2.500	1.508
2.750	1.459
3.000	1.403
3.250	1.340
3.500	1.268
3.750	1.186
4.000	1.092
4.250	.981
4.500	.848
4.750	.680
5.000	.438
5.170	.000

PARTS LIST

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	DESCRIPTION	ZONE	ITEM NO.
					12
					11
					10
4		-15-01	STEEL, 4130, PER MIL-S-6758, COND A		9
1		-14-01			8
1		-13-01			7
1		-12-01	STEEL, 4130, PER MIL-S-6758, COND A		6
1		-11-01	STEEL, 4130, PER MIL-S-18729, COND A		5
					4
					3
					2
		-01-01	WELDMENT		1

DASH NO.	PART NO.	NEXT ASSY
-01-01	C11202-01-01	C11224

United Technology Center

CLOSURE, FWD

SIZE	CODE IDENT NO.	DRAWING NO.	REV
E	14134	C11202	A

SCALE 1/1 SHEET 1 OF 1

CLASS ______ CRBD ______ DWR 2901

DRAWING/~~SPECIFICATION~~ NO. C11202 A/1	REV	ENGINEERING CHANGE ORDER United Technology Center UA			PROJ. NO. 3992	E.C.O. 19379
TITLE CLOSURE, FWD					14134 CODE IDENT NO.	SHEET 1 OF 1
		PROJECT MANAGER		CHANGE CONTROL	RELEASE FORM NO. 16215-516	DATE 9-22-75
PREPARED Swinney DATE 9-8-75	DESIGN ENGINEER [illegible] 9/17/75	PROJECT ENGINEER [illegible] 9-17-75	QUALITY CONTROL [illegible] 9/19/75		APPROVAL	APPROVAL
CHECKED [illegible] DATE 9-15-75	ANALYSIS [illegible] 9/17/75		MATERIALS [illegible] 9/17/75	SAFETY		

(1) ON F/D, ZONES 6/B & 7/C, ADDED TRUE POSITION CALLOUT TO ITEMS 6, 7 & 8 CALLOUTS: $\boxed{\oplus \mid B \mid .014\ DIA}$

(2) ON F/D, ZONE 8/D,

IS: 9 $\boxed{\oplus \mid .028\ DIA}$ TYP   WAS: 9

(3) ON F/D, ZONE 5/C, IS: ... × .30 DP...
WAS: ... × .300 DP...

REASON FOR CHANGE: TO REFLECT LATEST DIMENSION METHOD

DISPOSITION OF MATERIAL

UTC 519 (6/67)

FIG. B-4. (Contd.)

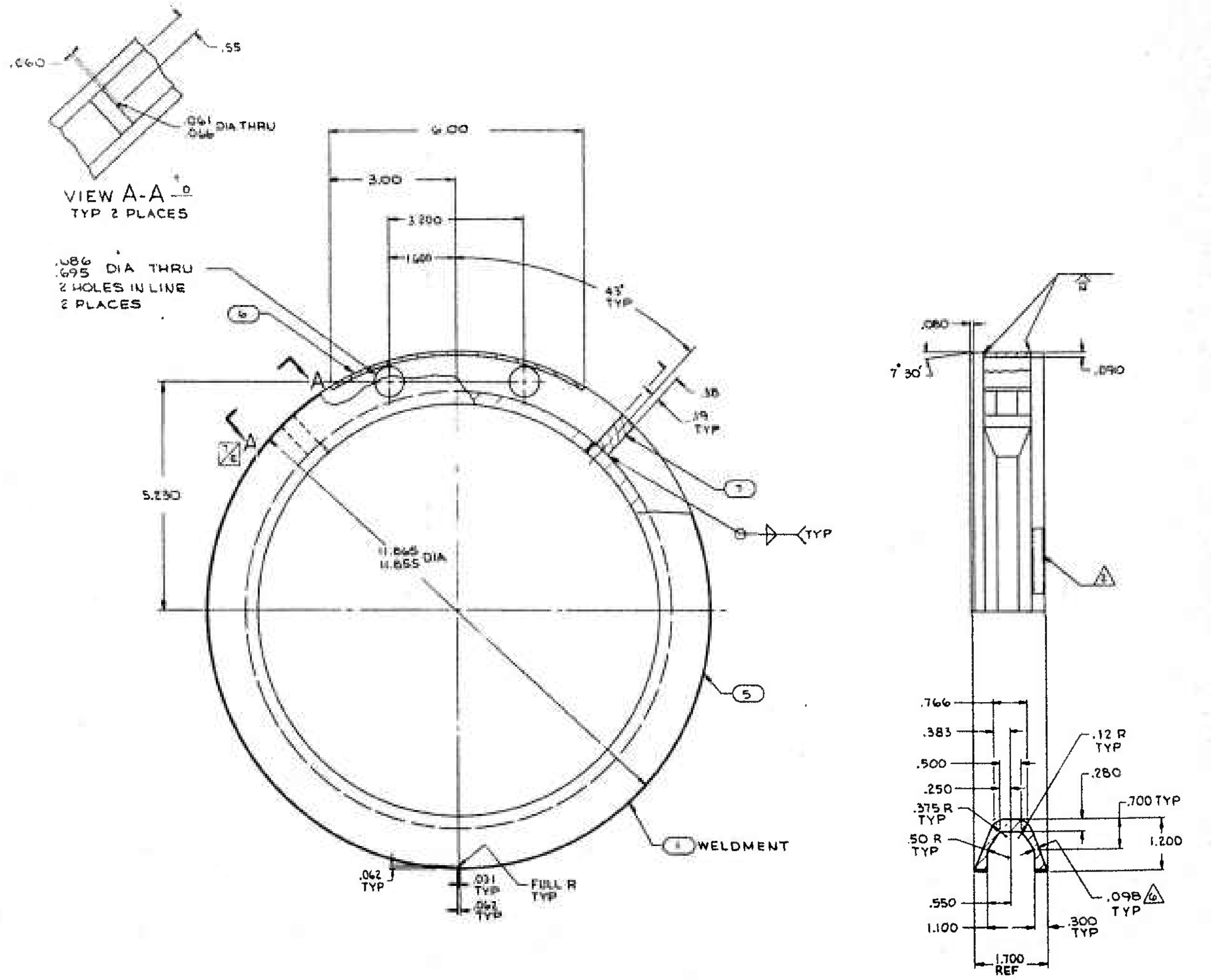
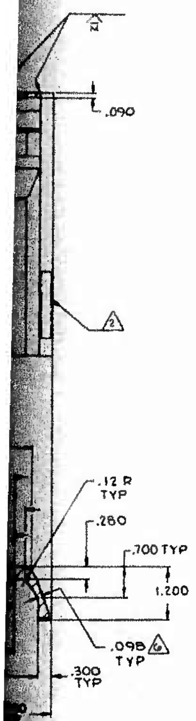


FIG. B-5. Ring, Forward.



NOTES

1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005 - .020.
2. RUBBER STAMP PART NO WITH 1/4 INCH HIGH CHARACTERS IN APPROX LOCATION SHOWN.
3. WELD PER MIL-W-8611. WELD DESIGN AND WELD PROCEDURE TO BE APPROVED BY UTC BEFORE ACTUAL HARDWARE IS WELDED.
4. FLUORESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-I-6868 ALL SURFACES 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA 5.1.2 METHOD OF MAGNETIZATION OPTIONAL. NO CRACKS OR DISCONTINUITIES ALLOWED.
5. HEAT TREAT PRIOR TO FINAL MACHINING TO 140,000 - 160,000 MINIMUM TENSILE STRENGTH PER MIL-H-6875. HARDNESS TO BE ROCKWELL C 34-39.
6. FOR QUALITY CONTROL INSPECTION ONLY. DO NOT FABRICATE TO THIS DIMENSION.

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
8/D		IS 5.230 WAS 5.170	[illegible]	[illegible]
WP		REMOVED: 5.780 DIA REF		
WP		REMOVED .060		

					9
					8
2		-13-01	STL, 4130 PER MIL-S-18729 COND N OR A	5/D	7
1		-14-01	STL, 4130 PER MIL-S-18729 COND N OR A	7/E	6
1		-15-01	STL, 4130 PER MIL-S-18729 COND N OR A	5/C	5
					4
					3
					2
X		-01-01	WELDMENT	5/B	1

PARTS LIST

CONTRACT NO. NOOO123-74-C-1387

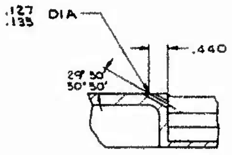
United Technology Center

RING, FORWARD

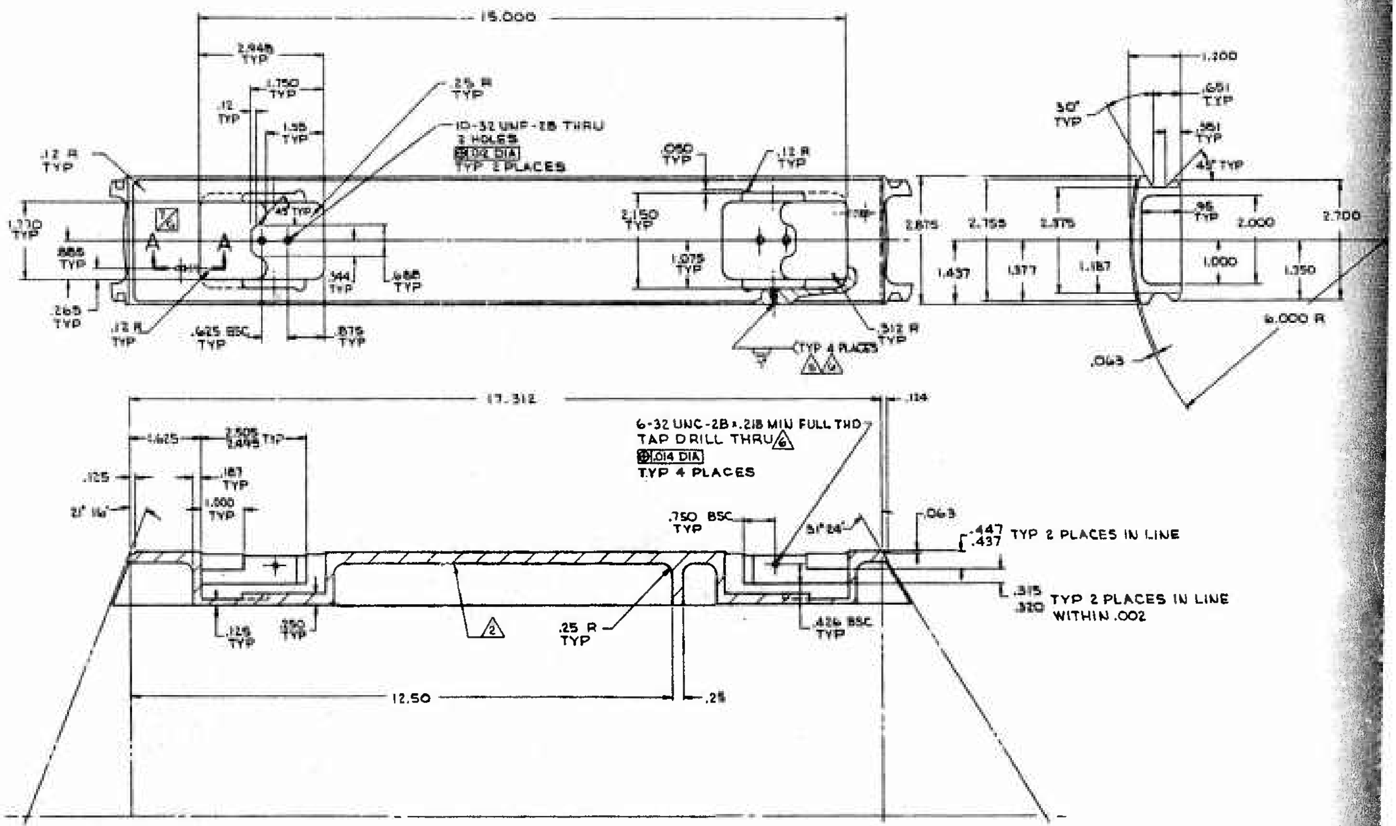
SIZE	CODE IDENT NO	DRAWING NO	REV
E	14134	C11203	A

SCALE 1/1

DASH NO.	PART NO.	NEXT ASSY
-01-01	C11203-01-01	C11204



SECTION A-A
TYP 2 PLACES



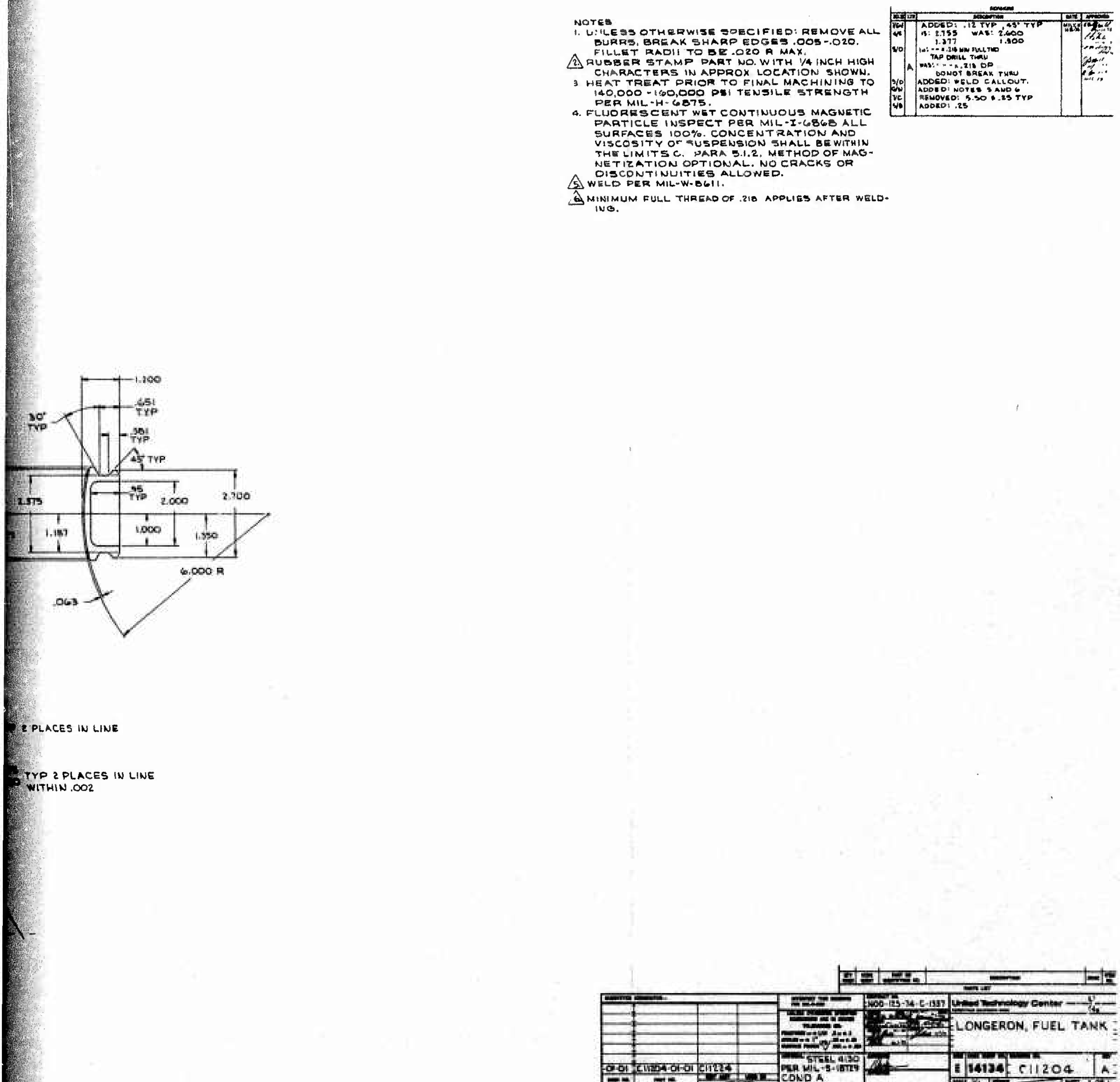


FIG. B-6. Longeron, Fuel Tank.

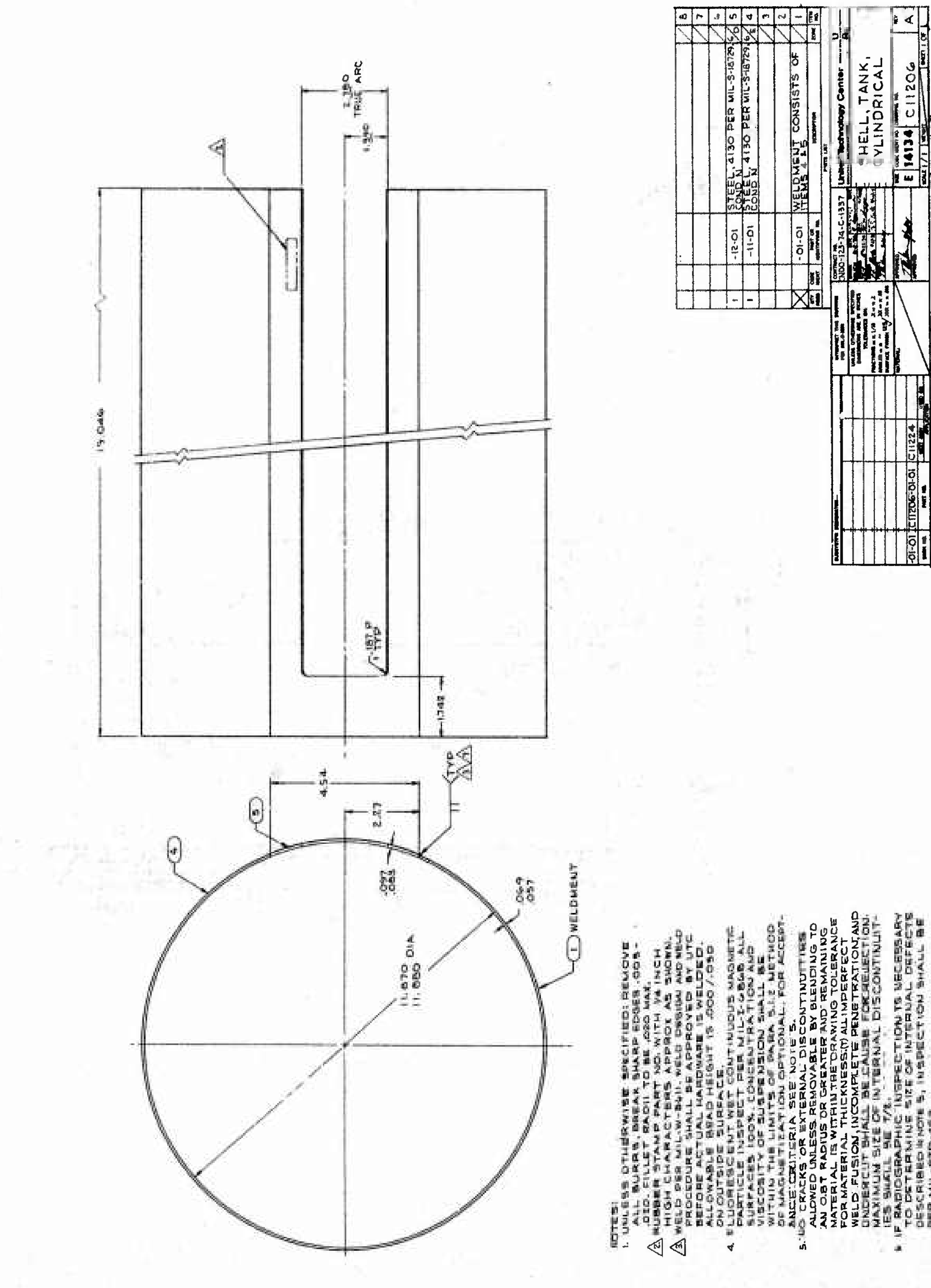


FIG. B-7. Shell, Tank, Cylindrical.

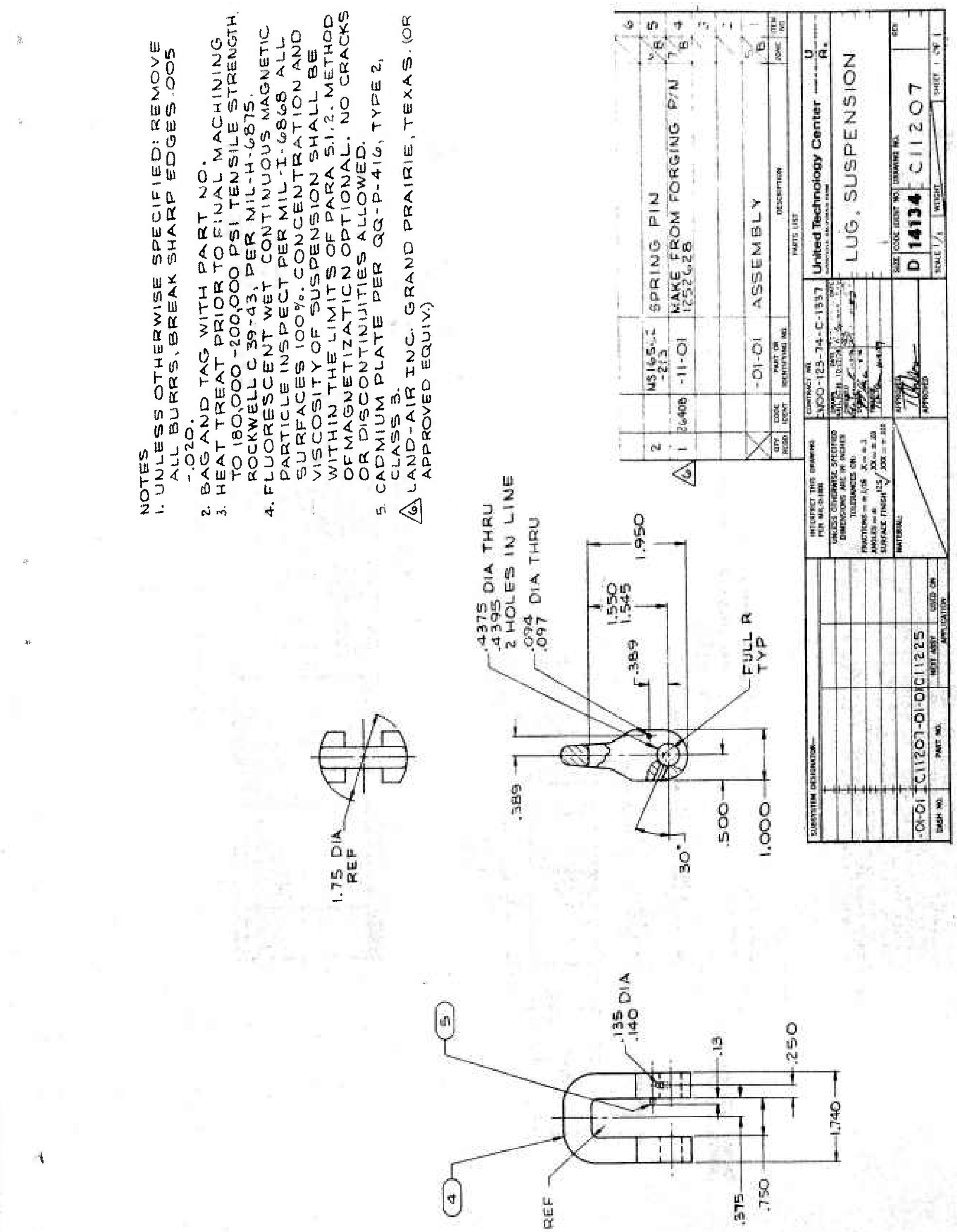


FIG. B-8. Lug, Suspension.

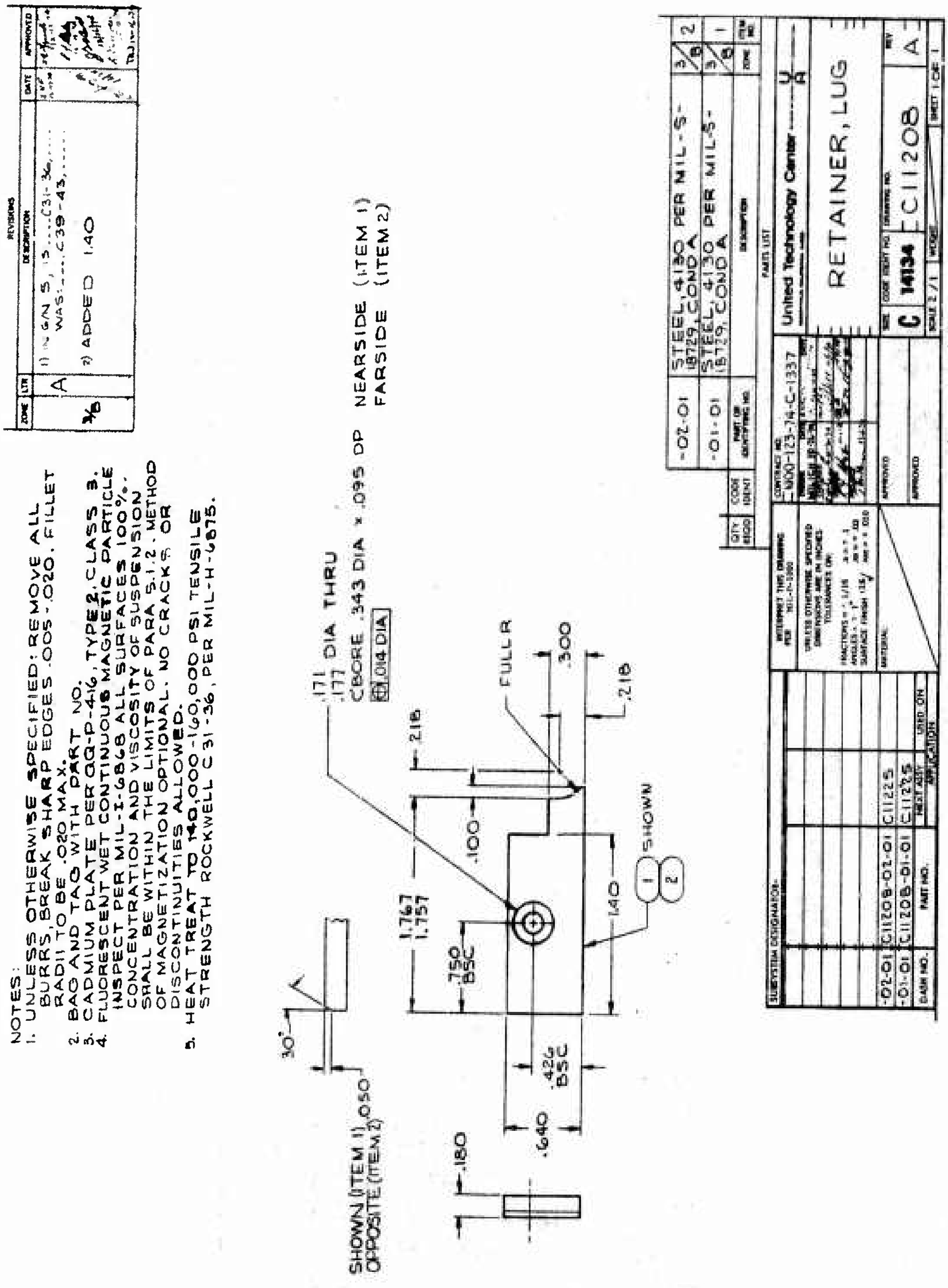
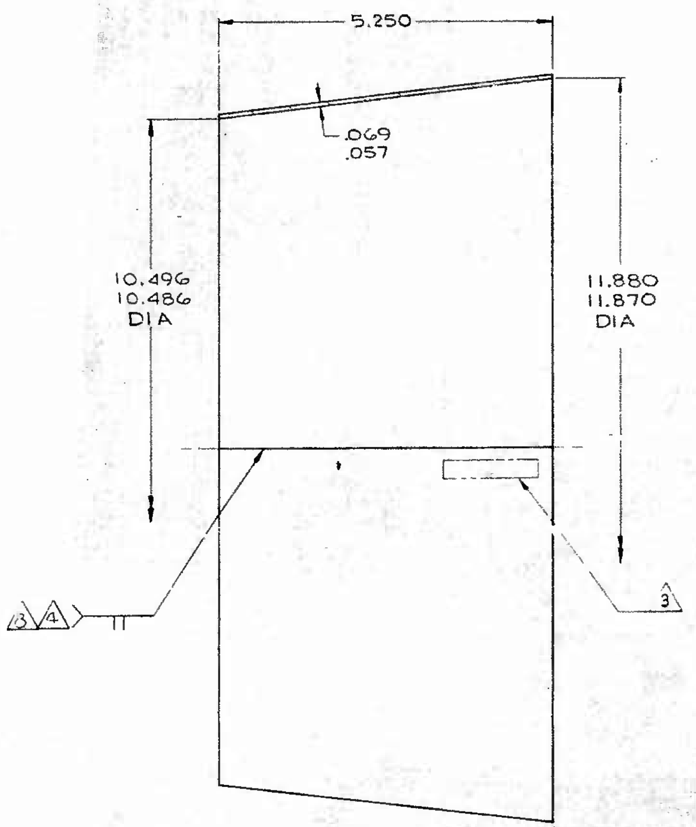


FIG. B-9. Retainer, Lug.



NOTES

1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005-.020.
2. DIMENSIONS APPLY IN THE RESTRAINED CONDITION.
3. RUBBER STAMP PART NO. WITH 1/4 INCH HIGH CHARACTERS APPROX AS SHOWN.
4. WELD PER MIL-W-8611. WELD DESIGN AND WELD PROCEDURE SHALL BE APPROVED BY UTC BEFORE ACTUAL HARDWARE IS WELDED. ALLOWABLE BEAD HEIGHT IS .000/.030 ON OUTSIDE SURFACE.
5. FLUORESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-I-6868 ALL SURFACES 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA 5.1.2. METHOD OF MAGNETIZATION OPTIONAL. FOR ACCEPTANCE CRITERIA SEE NOTE 6.
6. NO CRACKS OR EXTERNAL DISCONTINUITIES ALLOWED UNLESS REMOVABLE BY BLENDING TO AN 0.8T RADIUS OR GREATER AND REMAINING MATERIAL IS WITHIN THE DRAWING TOLERANCE FOR MATERIAL THICKNESS. (T) ALL IMPERFECT WELD FUSION, INCOMPLETE PENETRATION AND UNDERCUT SHALL BE CAUSE FOR REJECTION. MAXIMUM SIZE OF INTERNAL DISCONTINUITIES SHALL BE T/2.
7. IF RADIOGRAPHIC INSPECTION IS NECESSARY TO DETERMINE SIZE OF INTERNAL DEFECTS DESCRIBED IN NOTE 6, INSPECTION SHALL BE PER MIL-STD-453.
8. MAXIMUM ALLOWABLE WELD MISMATCH IS .010 ON LONGITUDINAL WELD.

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	DESCRIPTION	ZONE	ITEM NO.
PARTS LIST					

SUBSYSTEM DESIGNATOR—

DASH NO.	PART NO.	NEXT ASSY	USED ON
-01-01	C11209-01-01		
		APPLICATION	

INTERPRET THIS DRAWING PER MIL-D-1000

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: FRACTIONS = ± 1/16 .X = ± .1 ANGLES = ± — .XX = ± .03 SURFACE FINISH 125/ .XXX = ± .010

MATERIAL STL, 4130 PER MIL-S-18729, COND N

CONTRACT NO. N00-123-74-C-1337

DRAWN MILICH 9-2-74

APPROVED

United Technology Center

SHELL, TANK, FWD

SIZE D | CODE IDENT NO. 14134 | DRAWING NO. C11209 | REV

SCALE 1/1 | WEIGHT | SHEET 1 OF 1

FIG. B-10. Shell, Tank, Forward.

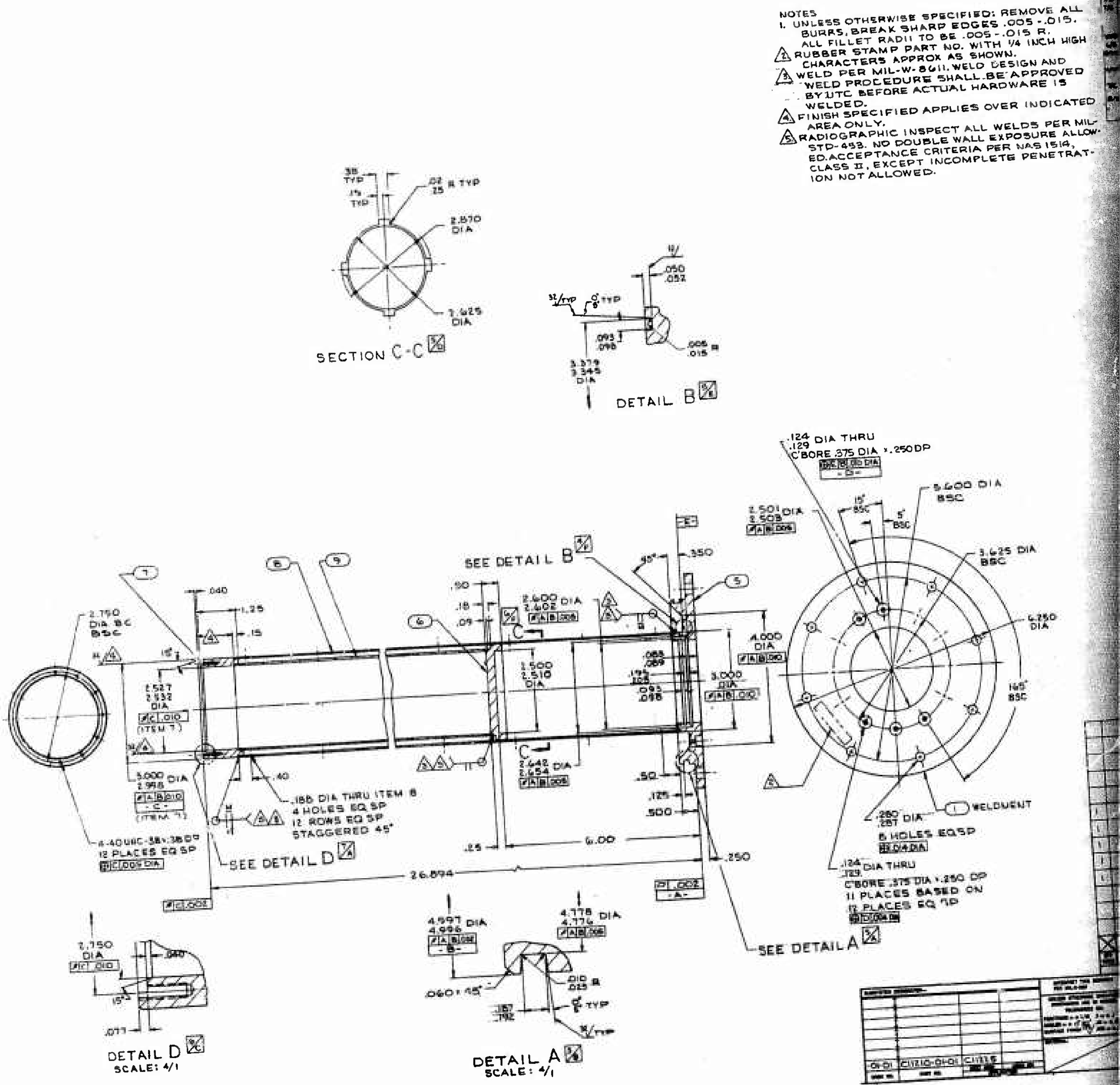


FIG. B-11. Collector Pipe Assembly.

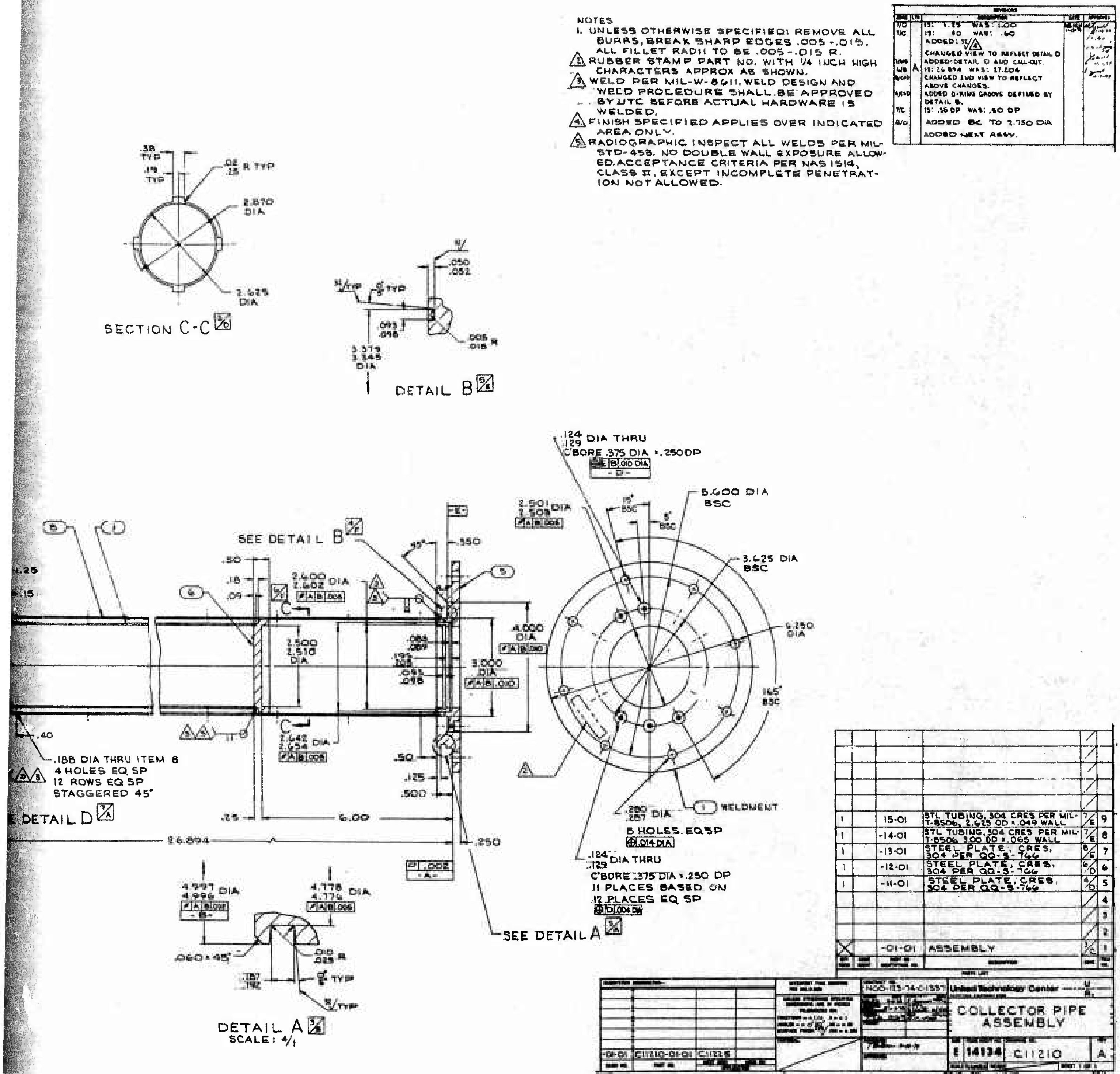


FIG. B-11. Collector Pipe Assembly.

CLASS ______ CRBD ______ DWR 2387

DRAWING/~~SPECIFICATION~~ NO. C11210 A/1	REV	ENGINEERING CHANGE ORDER		PROJ. NO. 3225	E.C.O. 18851
TITLE COLLECTOR PIPE ASSEMBLY		United Technology Center UA		14134 CODE IDENT NO.	SHEET 1 OF 1
		PROJECT MANAGER T. Wan 11-21-74	CHANGE CONTROL	RELEASE FORM NO. 15780-516-	DATE 11-25-74
PREPARED FITZ DATE 11-21-74	DESIGN ENGINEER 11-21-74	PROJECT ENGINEER T. Wan	QUALITY CONTROL 11/25/74	APPROVAL	APPROVAL
CHECKED DATE 11-21	ANALYSIS N/A TOW 11-21-74		MATERIALS 11/21/74 / SAFETY		

REVISED DWG AS FOLLOWS:

LIMITED EFFECTIVITY: APPLIES TO PART NO C11210-01-01, SERIAL NO. 001 THRU 008

1) ON F/D ZONE 8/C

IS: 2.998 / 2.996 DIA WAS: 3.000 / 2.998 DIA

REASON FOR CHANGE
VENDOR MACHINED MATING PART WRONG (3.000/3.001)

DISPOSITION OF MATERIAL

UTC 519 (6/67)

FIG. B-11. (Contd.)

CLASS ______ CRBD ______ DWR 2387

DRAWING/~~SPECIFICATION~~ NO. C11210 A/2	REV	ENGINEERING CHANGE ORDER	PROJ. NO. 2516	E.C.O. 18869
TITLE COLLECTOR PIPE ASSEMBLY		United Technology Center UA	14134 CODE IDENT NO.	SHEET 1 OF 1

		PROJECT MANAGER [signature] 1-7-75		CHANGE CONTROL	RELEASE FORM NO. 15836-516- DATE 1-20-75
PREPARED MILICH DATE 1-15-75	DESIGN ENGINEER [signature] 1-15-75	PROJECT ENGINEER T. Wam 1-17-75	QUALITY CONTROL [signature] 1/15/75		APPROVAL / APPROVAL
CHECKED [signature] DATE 1-15-75	ANALYSIS R. [signature] 1-17-75		MATERIALS [signature] 1/17/75	SAFETY B. [signature] 1-17-75	

REVISED DWG AS FOLLOWS

1.) ON F/D, ZONE 3/B,C

IS:
$\frac{.280}{.287}$ DIA THRU
CSK 82° x .531 DIA
8 PLACES EQ SP
⊕ .014 DIA

WAS:
$\frac{.280}{.287}$ DIA
8 HOLES EQ SP
⊕ .014 DIA

REASON FOR CHANGE SATISFY INTERFACE REQUIREMENT

DISPOSITION OF MATERIAL

UTC 519 (6/67)

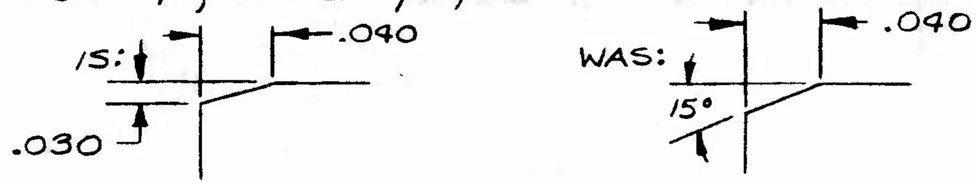
FIG. B-11. (Contd.)

CLASS ______ CRBD ______ DWR 2623

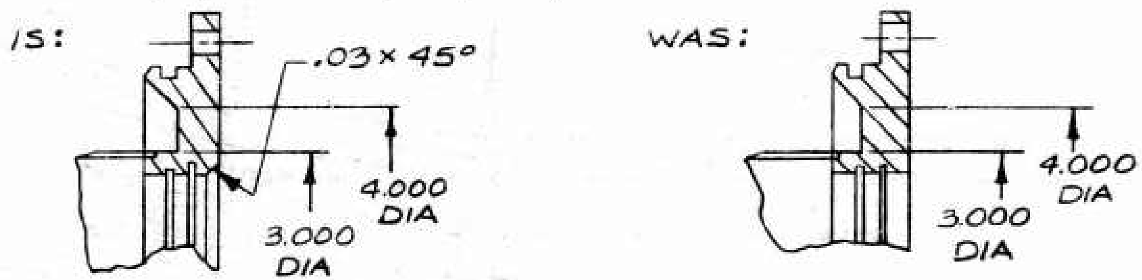
DRAWING/~~SPECIFICATION~~ NO. C11210 A/3	REV	**ENGINEERING CHANGE ORDER** United Technology Center	PROJ. NO. 3990 E.C.O. 18875
TITLE COLLECTOR PIPE ASSY		U A	14134 CODE IDENT NO. — SHEET 1 OF 1
PREPARED Abbott DATE 2-10-75	DESIGN ENGINEER 2-14-75	PROJECT MANAGER 2-17-75	CHANGE CONTROL	RELEASE FORM NO. 15870-516- DATE 2-19-75
CHECKED DATE 2-14-75	ANALYSIS 2-17-75	PROJECT ENGINEER 2-17-75 — QUALITY CONTROL 2/14/75 — MATERIALS 2/14/75	SAFETY	APPROVAL — APPROVAL

REVISED DWG AS FOLLOWS:

1. ON F/D, ZONE 7/D,



2. ON F/D, ZONE 4/D & 4/C, REVISED PICTURE:



REASON FOR CHANGE: DESIGN IMPROVEMENT

DISPOSITION OF MATERIAL

UTC 519 (6/67)

FIG. B-11. (Contd.)

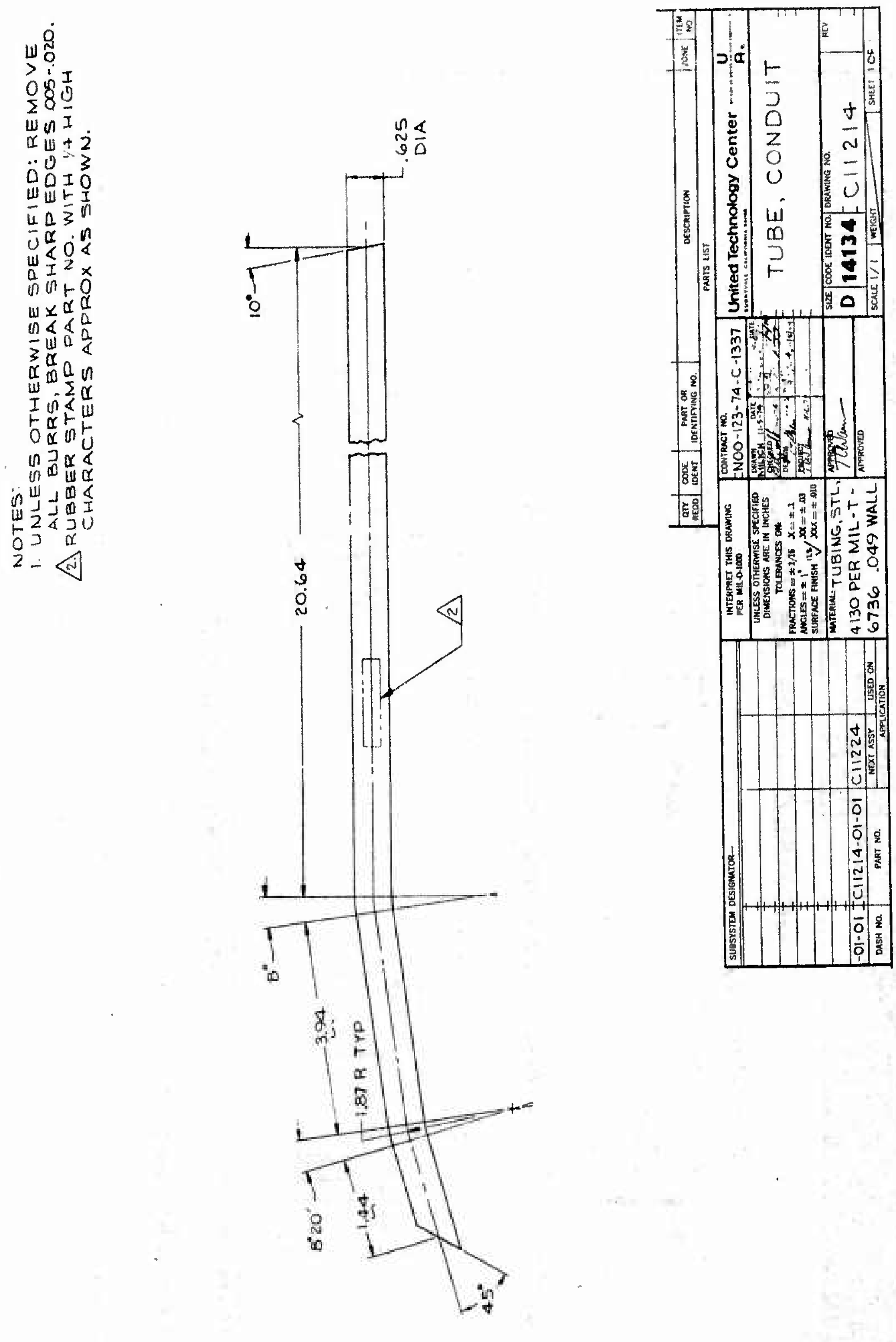
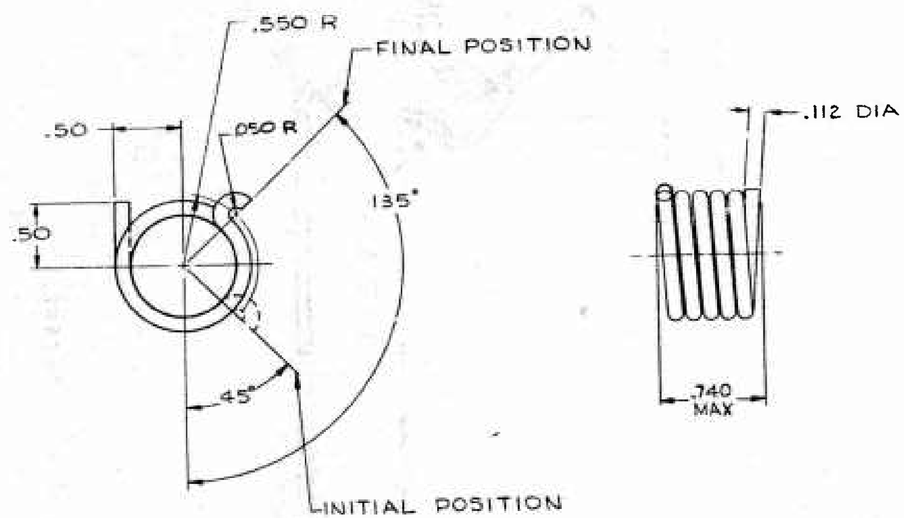


FIG. B-12. Tube, Conduit.

NOTES:
1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS, BREAK SHARP EDGES .005 -.020.
2. BAG AND TAG WITH PART NO.
3. MANDATORY SPECIFICATIONS:
   MAX SPRING OD: 1.000 DIA
   MIN SPRING ID: .687 DIA
   SPRING WORKS OVER .630 DIA SHAFT.
   TORQUE AT:
     FINAL POSITION: 28±2 IN.LB.
     INITIAL POSITION: O IN.LB.
   DIRECTION OF HELIX: RIGHT HAND
   TOTAL COILS: 4.62 REF



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	DESCRIPTION	ZONE	ITEM NO

PARTS LIST

SUBSYSTEM DESIGNATOR—

DASH NO.	PART NO.	NEXT ASSY	USED ON
-01-01	C11215-01-01	C11225	

APPLICATION

INTERPRET THIS DRAWING PER MIL-D-1000

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
FRACTIONS = ±1/16 X = ±.1
ANGLES = ± 1° XX = ±.03
SURFACE FINISH 125 XXX = ±.010

MATERIAL: STEEL WIRE PER ASTM-A-228, PHOSPHATE COATED

CONTRACT NO.

DRAWN / CHECKED / DESIGN / PROJECT / DATE

APPROVED

APPROVED

United Technology Center

U
R.

SPRING, HELICAL, TORSION

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D	14134	C11215	

SCALE 2/1 | WEIGHT | SHEET 1 OF 1

FIG. B-13. Spring, Helical, Torsion.

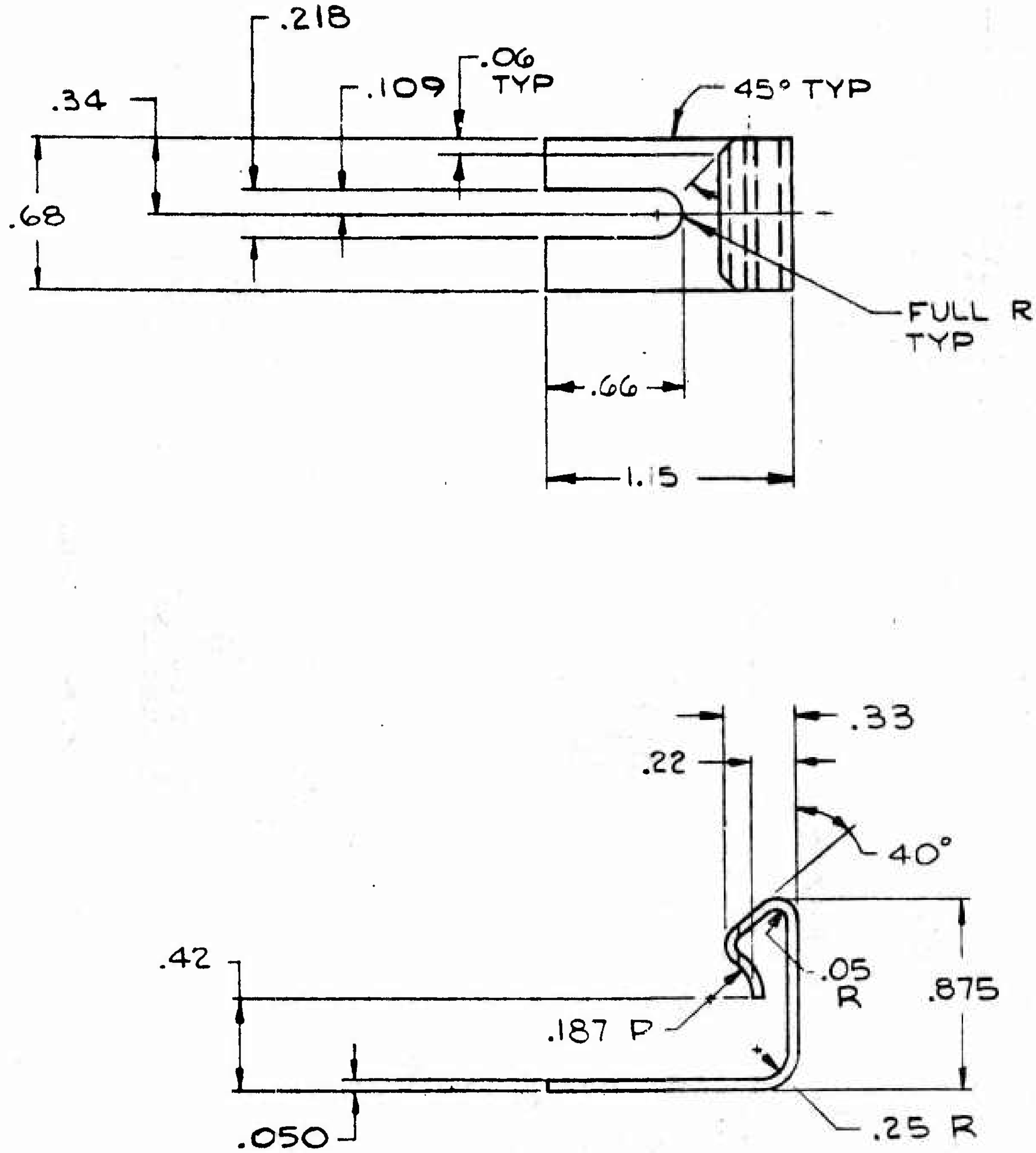


FIG. B-14. Spring, Flat.

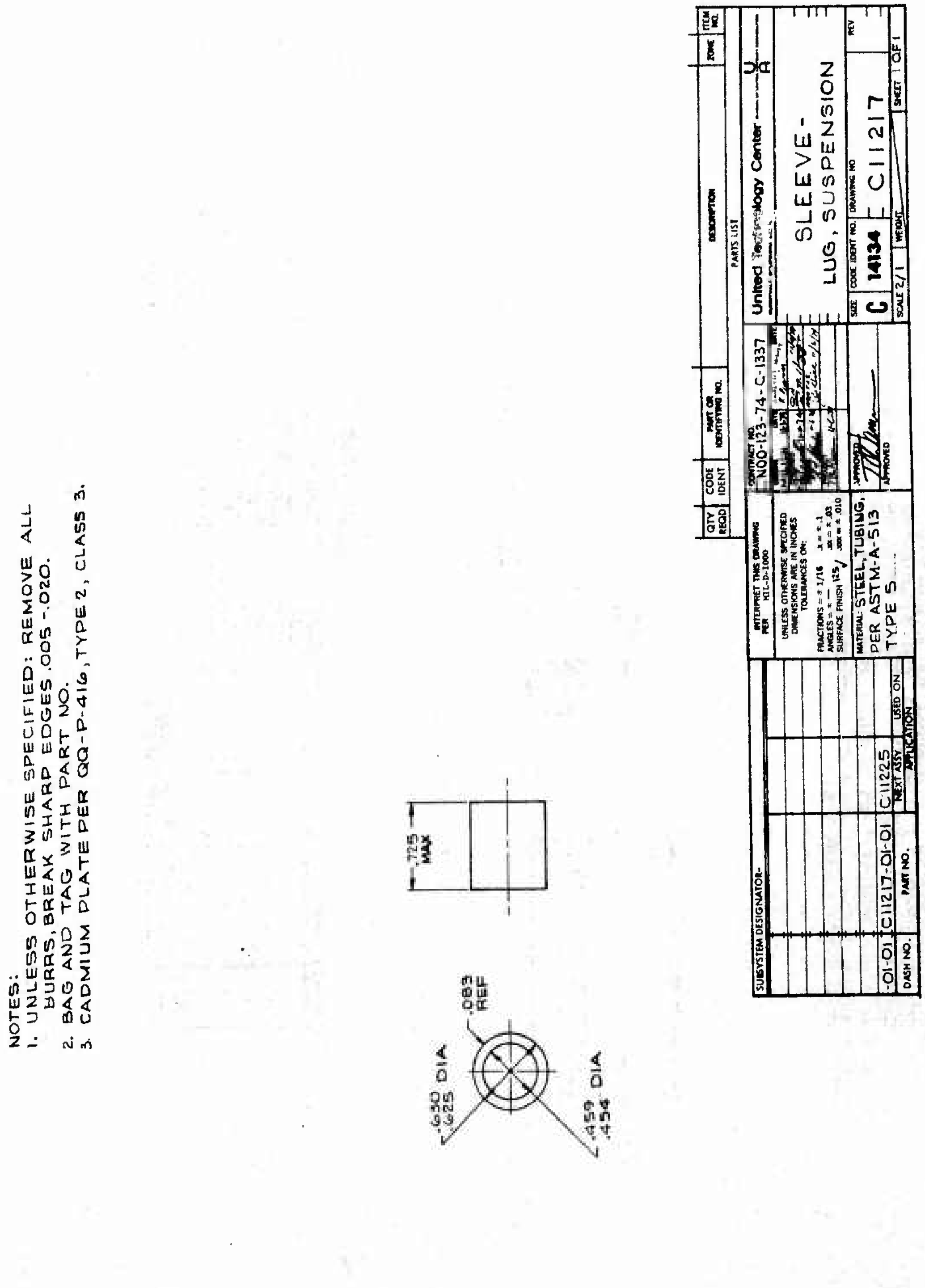


FIG. B-15. Sleeve, Lug, Suspension.

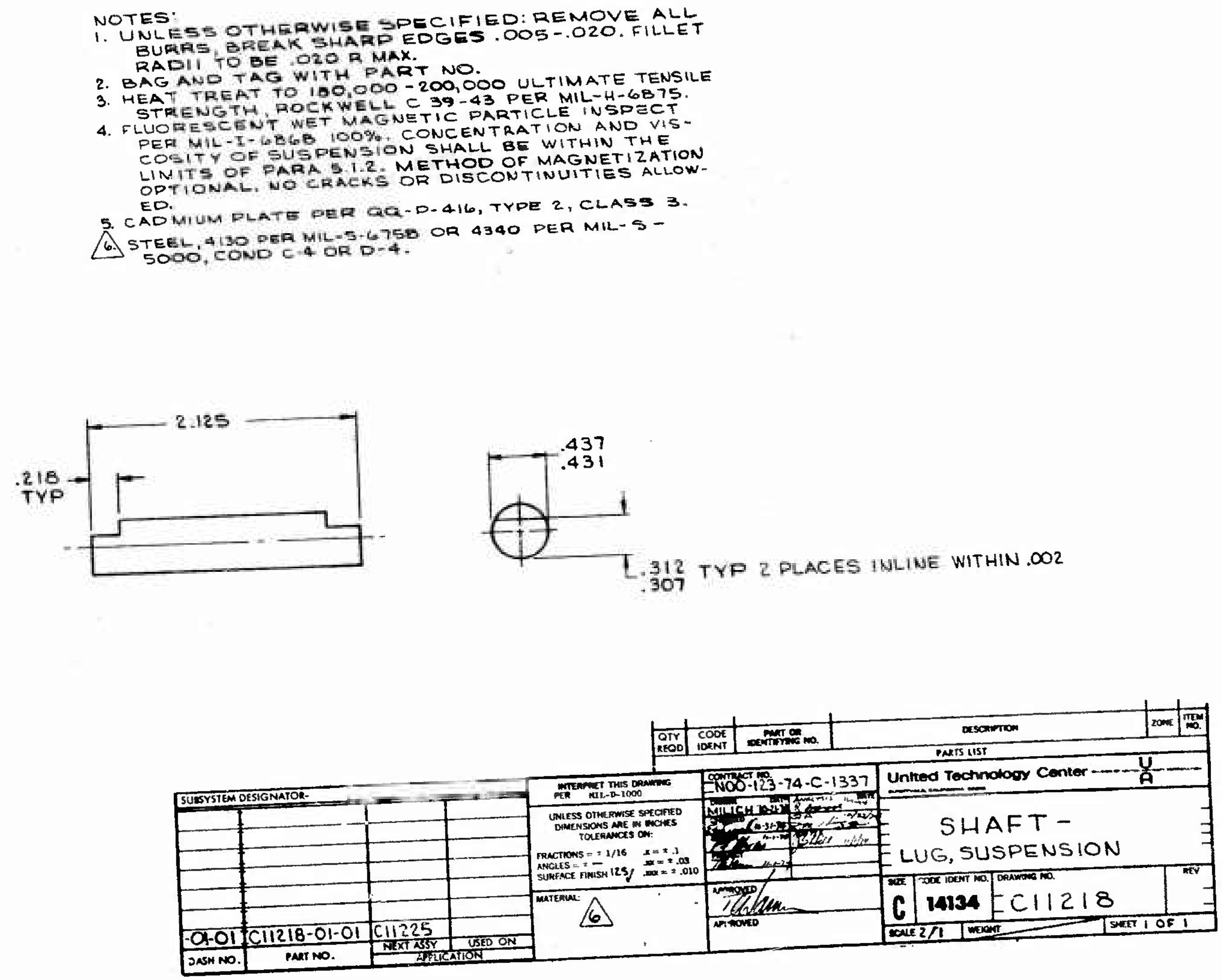


FIG. B-16. Shaft, Lug, Suspension.

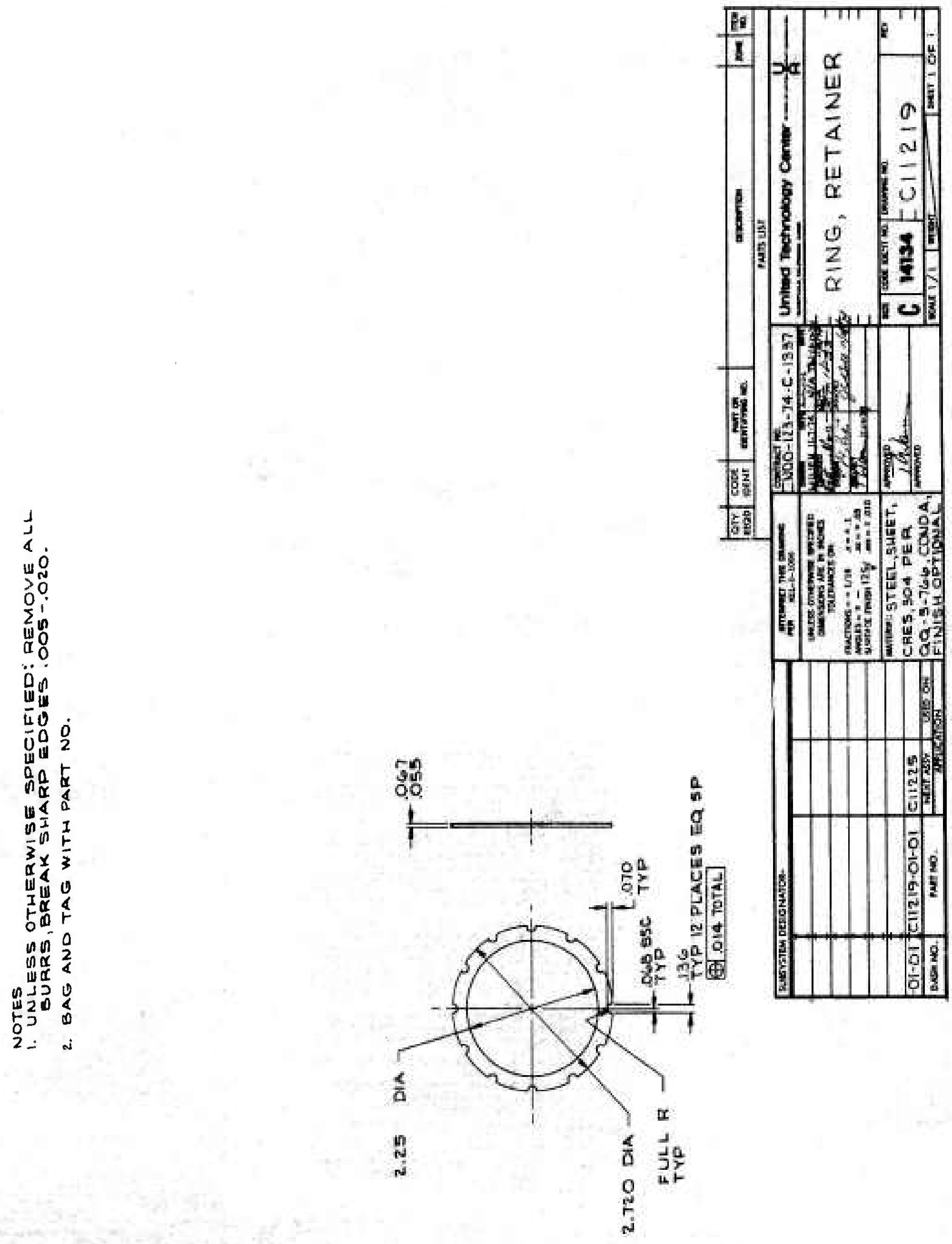


FIG. B-17. Ring, Retainer.

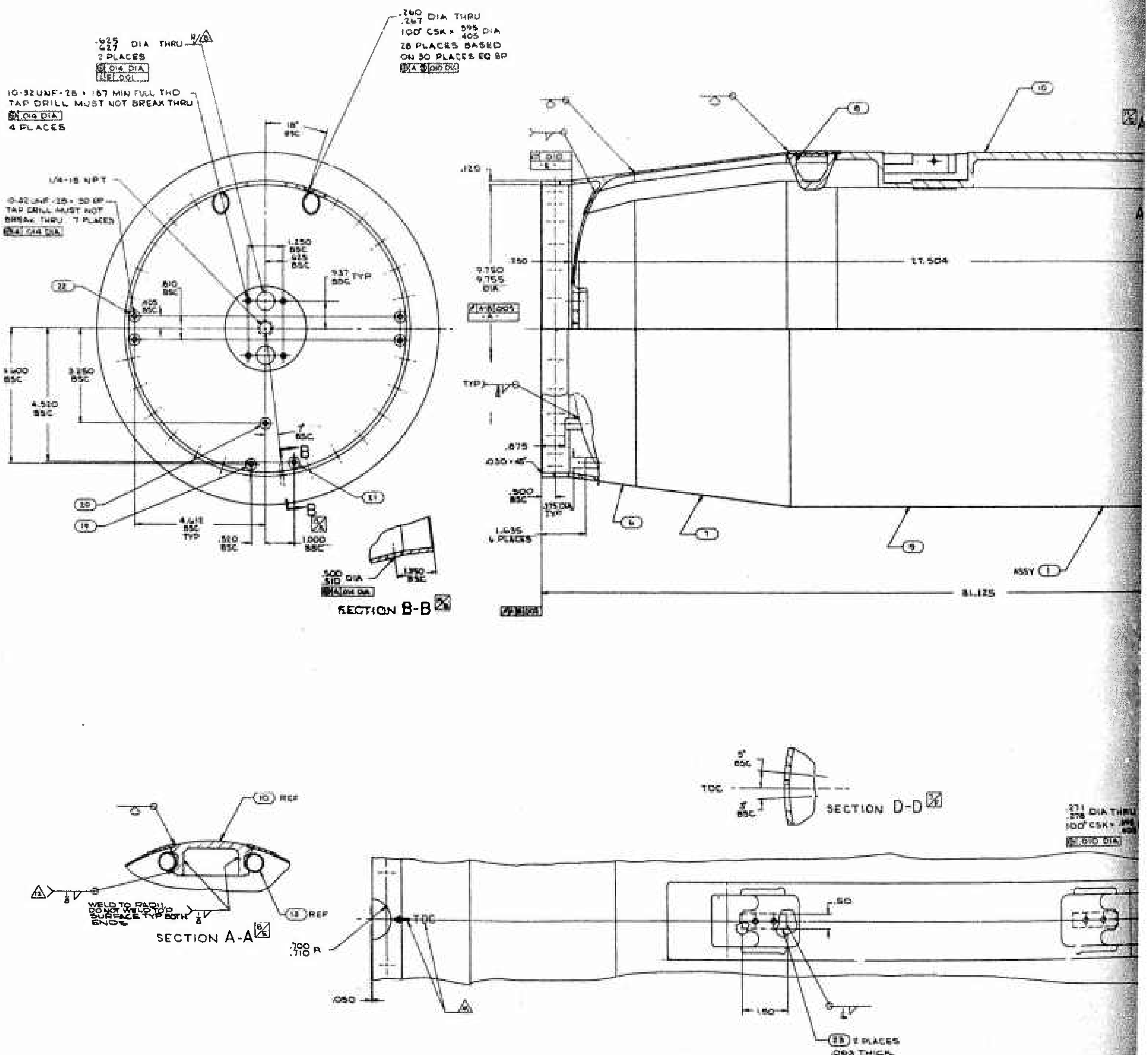
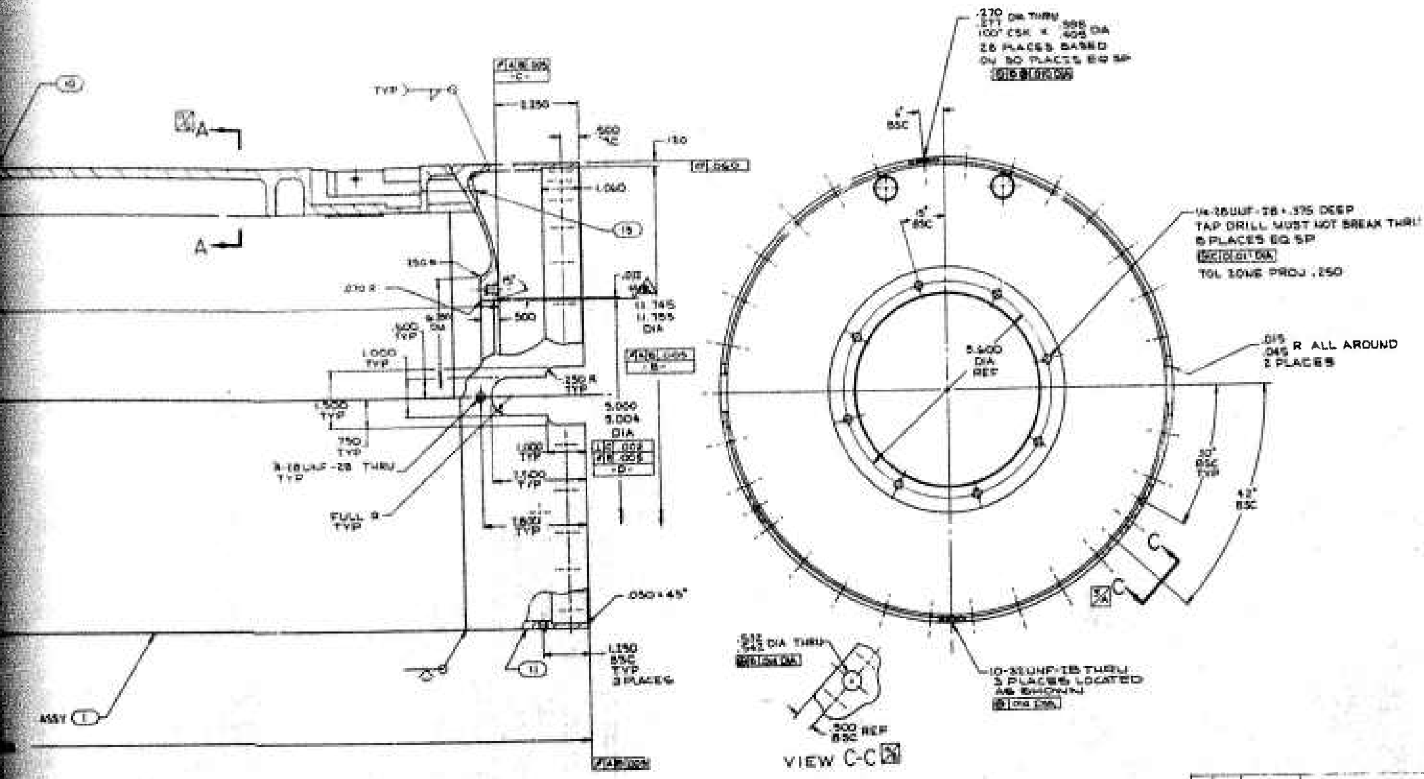
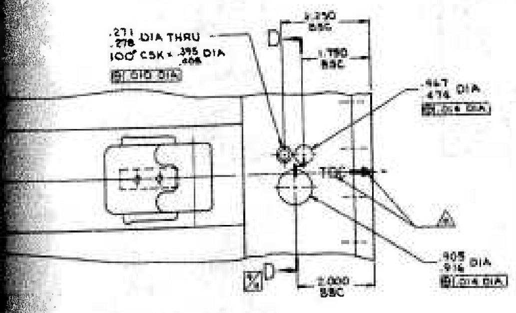


FIG. B-18. Fuel Tank.





NOTES:
1. UNLESS OTHERWISE SPECIFIED: REMOVE ALL BURRS. BREAK ALL SHARP EDGES .005-.020. FILLET RADII TO BE .020 MAX.
2. ALL DIMENSIONS APPLY AT 68°F AFTER WELDING AND FINAL MACHINING IN THE UNRESTRAINED CONDITION.
3. WELD PER MIL-W-8611. WELD DESIGN AND WELD PROCEDURE SHALL BE APPROVED BY UTC BEFORE ACTUAL HARDWARE IS WELDED. ALLOWABLE BEAD HEIGHT IS .000/.030 ON OUTSIDE SURFACES.
4. FLUORESCENT WET CONTINUOUS MAGNETIC PARTICLE INSPECT PER MIL-I-6868 ALL WELDS 100%. CONCENTRATION AND VISCOSITY OF SUSPENSION SHALL BE WITHIN THE LIMITS OF PARA 3.1.2. METHOD OF MAGNETIZATION OPTIONAL. FOR ACCEPTANCE CRITERIA SEE NOTE 5.
5. NO CRACKS OR EXTERNAL DISCONTINUITIES ALLOWED UNLESS REMOVABLE BY BLENDING TO AN 0.8T RADIUS OR GREATER AND REMAINING MATERIAL IS WITHIN THE DRAWING TOLERANCE FOR MATERIAL THICKNESS (T). ALL IMPERFECT WELD FUSION, INCOMPLETE PENETRATION AND UNDERCUT SHALL BE CAUSE FOR REJECTION. MAXIMUM SIZE OF INTERNAL DISCONTINUITIES SHALL BE T/2.
6. IF RADIOGRAPHIC INSPECTION IS NECESSARY TO DETERMINE SIZE OF INTERNAL DEFECTS DESCRIBED IN NOTE 5, INSPECTION SHALL BE PER MIL-STD-453.
7. COAT ALL EXTERIOR SURFACES INCLUDING THREADED HOLES WITH ITEM 27.
8. NO TOOL CHATTER MARKS, PITS, RUST OR SCRATCHES PERMITTED ON INDICATED SURFACES.
9. WD-40 CO, SAN DIEGO, CA (OR APVD EQUIV).
10. RUBBER STAMP ARROW AND LETTERS APPROX AS SHOWN.
11. HYDROSTATIC TEST PART PER C11223.
12. WELD MUST NOT INTERFERE WITH ITEM 13 AT ASSEMBLY, FILLET SIZE MAY VARY AS REQD.

QTY	CODE	PART NO.	DESCRIPTION		ITEM
AR	09357	WD-40	LUBRICATING OIL		27
2		-15-01	STEEL, 4130 PER MIL-S-18729 COND N OR A (.80 x 1.50 x .063)	9/F	23
6		-14-01	STEEL, 4130, PER MIL-S-6758 COND A	15/C	22
1		-13-01		13/B	21
1		-12-01		15/B	20
1		-11-01	STEEL, 4130, PER MIL-S-6758 COND A	15/B	19
1		C11214-01-01	TUBE		13
1		C11201-01-01	CLOSURE, AFT		11
1		C11204-01-01	LONGERON, FUEL TANK		10
1		C11206-01-01	SHELL, TANK, CYLINDRICAL		9
1		C11208-01-01	RING, FWD		8
1		C11209-01-01	SHELL, TANK, FWD		7
1		C11208-01-01	CLOSURE, FWD		6
		-01-01	ASSEMBLY	9/A	1

REVISION A: .395/.405 DIA WAS .310/.405 DIA

NO0-I23-74C-1357

United Technology Center

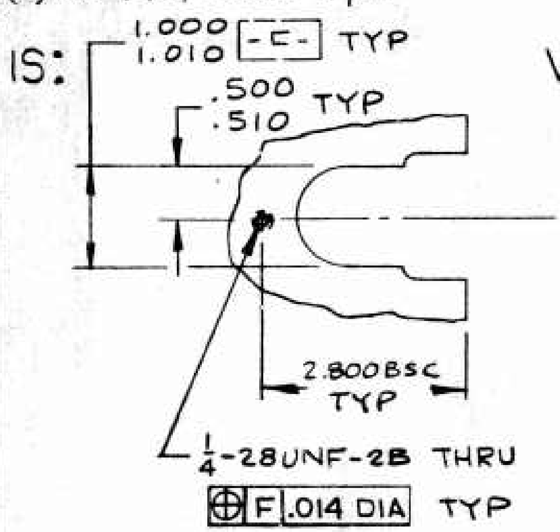
FUEL TANK

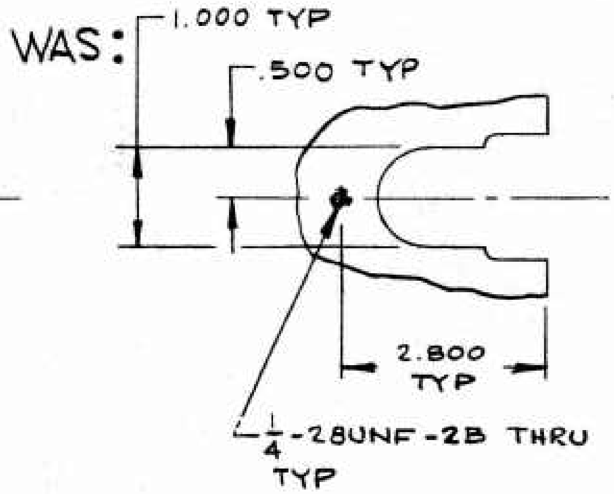
J 14134 C11224 A

CLASS ______ CRBD ______ DWR 2901

DRAWING/~~SPECIFICATION~~ NO. C11224 B/1	REV	**ENGINEERING CHANGE ORDER** United Technology Center U A	PROJ. NO. 3992	E.C.O. 19378
TITLE FUEL TANK			14134 CODE IDENT NO.	SHEET 1 OF 1
		PROJECT MANAGER / CHANGE CONTROL	RELEASE FORM NO. 16215-516	DATE 9-22-75
PREPARED DATE 9-8-75	DESIGN ENGINEER 9/12/75	PROJECT ENGINEER 9-17-75 / QUALITY CONTROL 9/19/75	APPROVAL	APPROVAL
CHECKED DATE 9-15-75	ANALYSIS 9/17/75	MATERIALS 9/17/75 / SAFETY		

(1) ON F/D, ZONE 7/C





REASON FOR CHANGE TO REFLECT LATEST PART DIMENSIONING METHOD

DISPOSITION OF MATERIAL

UTC 519 (6/67)

FIG. B-18. (Contd.)

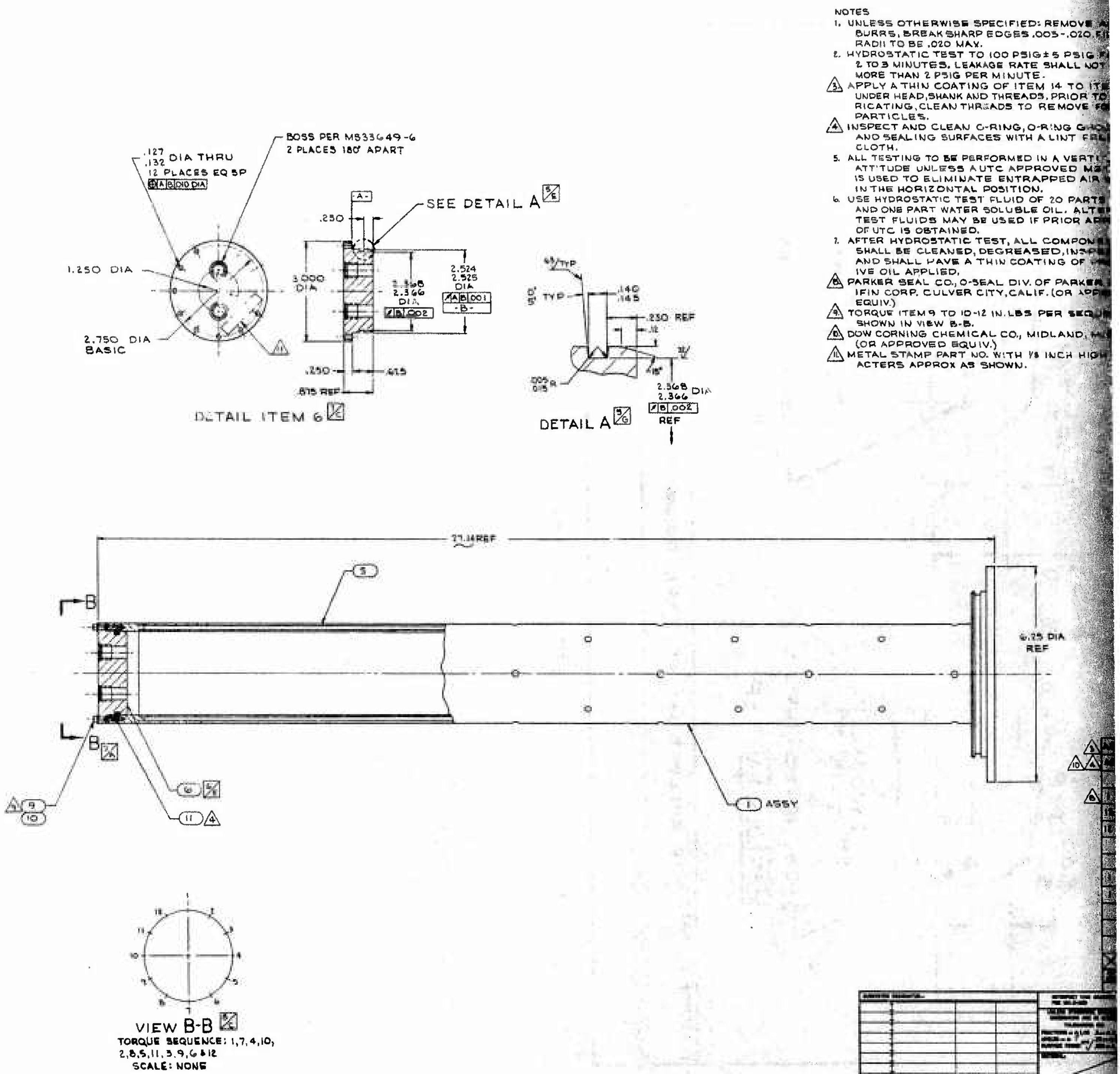
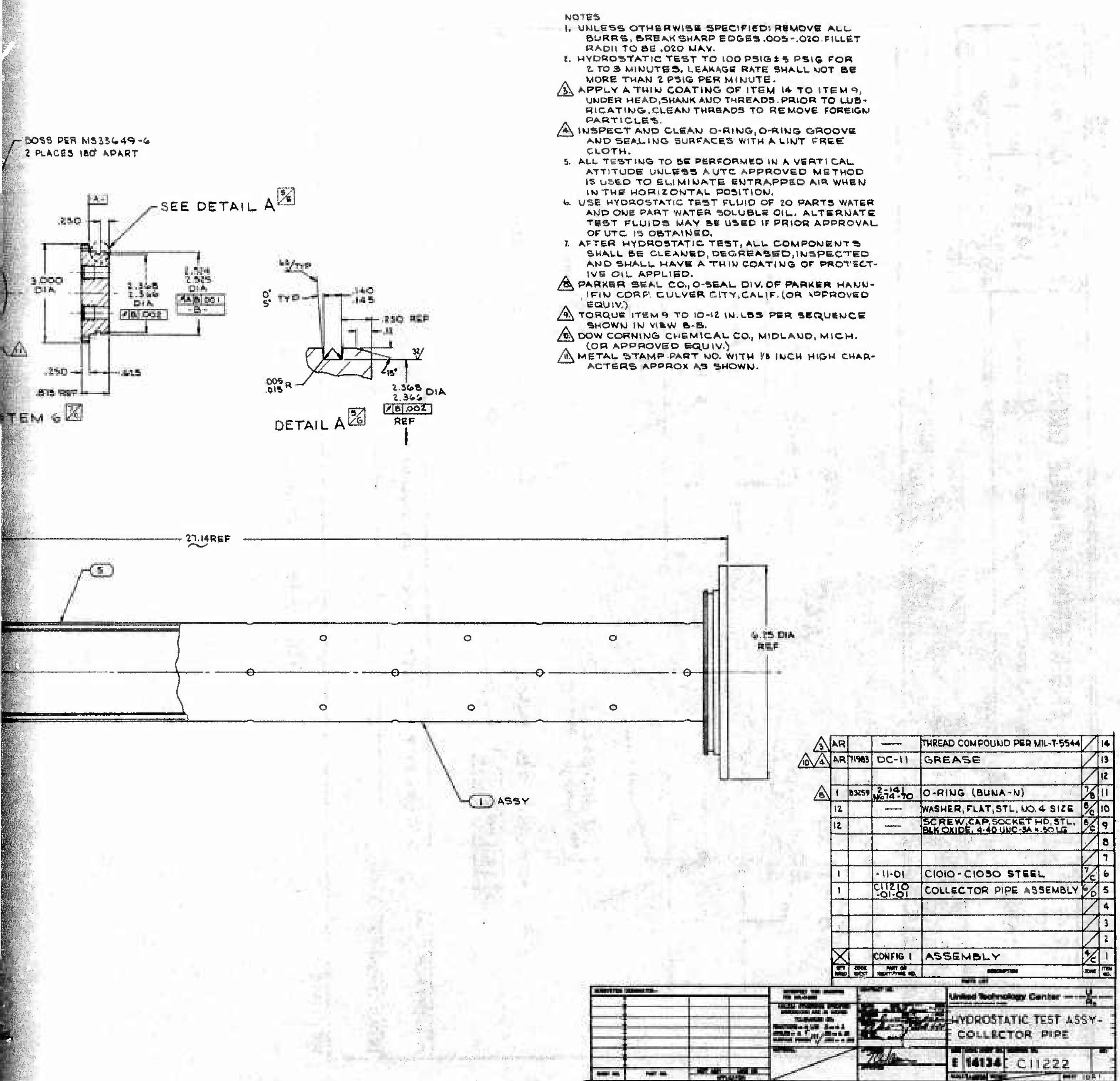
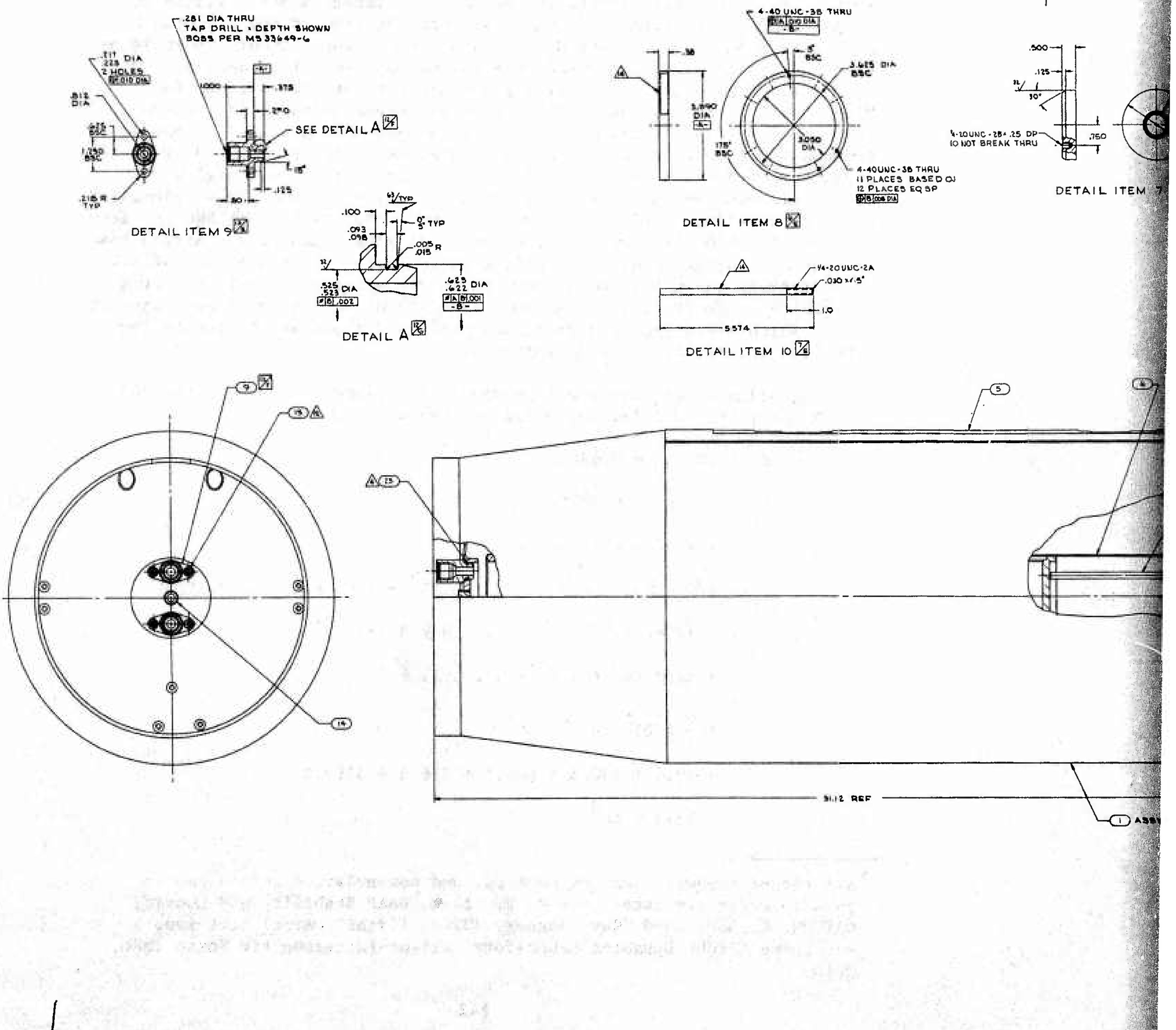


FIG. B-19. Hydrostatic Test Assembly, Collector Pipe.



B-19. Hydrostatic Test Assembly, Collector Pipe.



.281 DIA THRU
TAP DRILL + DEPTH SHOWN
BOSS PER MS 33649-6
SEE DETAIL A
DETAIL ITEM 9
DETAIL A
4-40 UNC-3B THRU
3.625 DIA BSC
3.890 DIA
3.050 DIA
4-40UNC-3B THRU
11 PLACES BASED ON
12 PLACES EQ SP
DETAIL ITEM 8
1/4-20UNC-2A
5.574
DETAIL ITEM 10
1/4-20UNC-2B x .25 DP
DO NOT BREAK THRU
DETAIL ITEM 7
31.12 REF
ASSY

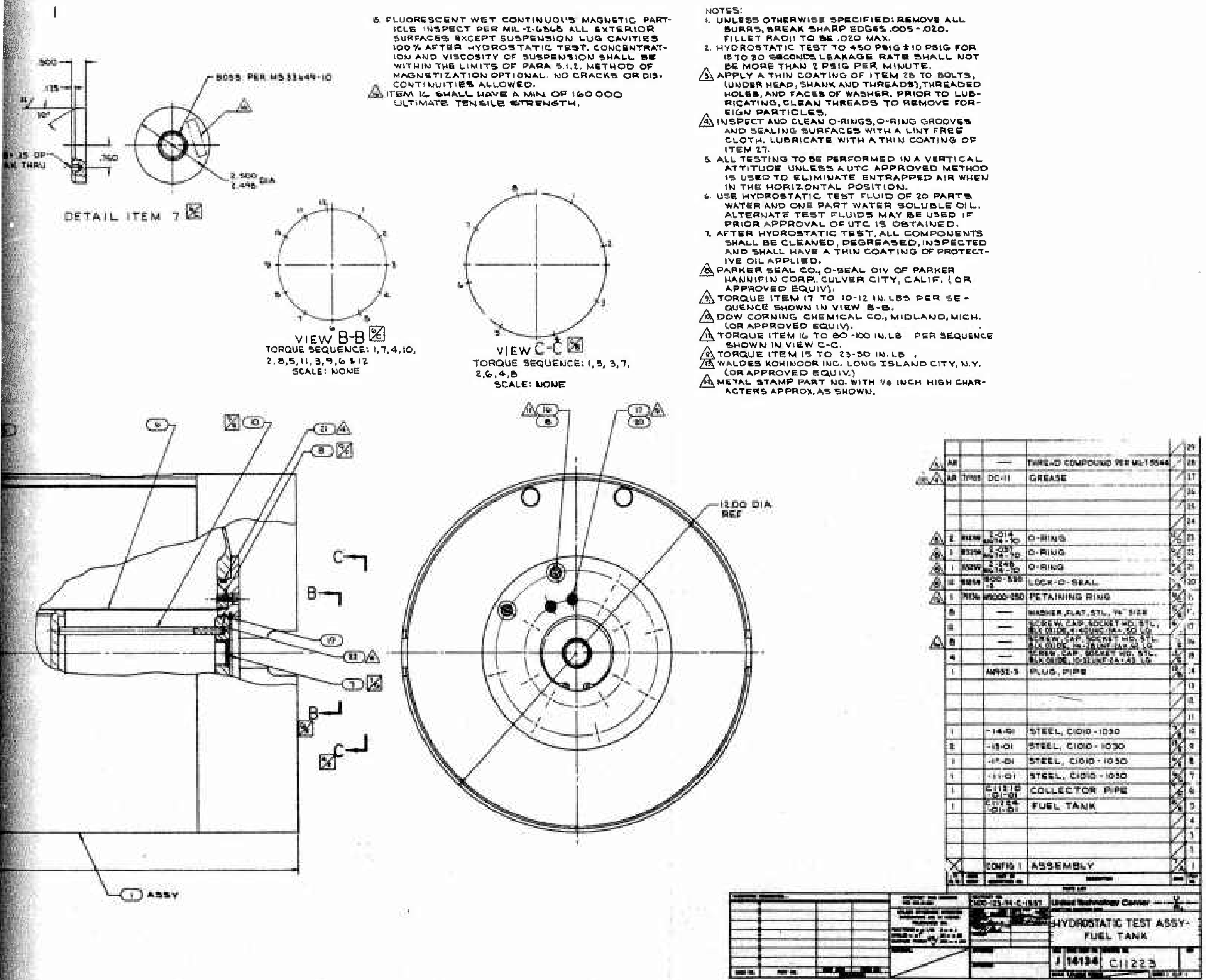


FIG. B-20. Hydrostatic Test Assembly, Fuel Tank.

Appendix C

AERODYNAMIC LOADS FOR GORJE

A complete structural analysis of the GORJE fuel tank assembly is necessary to determine the aerodynamic loads exerted on the fuel tank which result from aerodynamic forces on the forebody and the afterbody. In particular, the force and moment at both the forward and aft attach skirts is required. The aerodynamic loads are a function of the angle of attack which the vehicle experiences during captive flight on the launch aircraft. A method for determining the angle of attack is given in MIL-A-8591D dated 2 January 1968. However, examination of the recommended formulas for Points 2 and 6 (see Fig. 11 of MIL-A8591D) reveals that effective angles of attack of 48.3 and 43.6 degrees could be expected at a flight condition of M = 0.8, H = 5,000 ft (q = 788 lb/ft^2). These angles of attack are considered to be unrealistically large and the loads calculated using these values would not be appropriate. Discussion with NWC confirmed that MIL-A-8591D gives unrealistic angles of attack and it was agreed that the angle of attack should be limited to 20 degrees. An angle of attack of 20 degrees is in the range where nonlinear aerodynamic effects could be expected. However, it is assumed that linear aerodynamics will predict forces which are slightly higher than would occur and are therefore conservative for structural load purposes.

The value of C_{L_α} for the forebody is estimated using the method of DATCOM, section 4.2.1.1[a], following the example shown:

$$d = 10 \text{ in.} = 0.833 \text{ ft}$$

$$\ell_B = 80 \text{ in.} = 6.67 \text{ ft}$$

$$f = \ell_B/d = 6.67/0.833 = 8.01$$

$$\begin{aligned} V_B &= 1/3\pi\ (2.5)^2\ 4.5 + 1/3\pi\ (3.25^2 + 2.5^2 + 3.25 \times 2.5)\ 5 \\ &\quad + 1/3\pi\ (4.8^2 + 3.25^2 + 4.8 \times 3.25)\ 13 \\ &\quad + 1/3\pi\ (5^2 + 4.8^2 + 5 \times 4.8)\ 9.5 \\ &\quad + \frac{\pi}{4}\ (10)^2\ 48 \\ &= 29.4 + 130.5 + 669.5 + 716.3 + 3769.9 \\ &= 5315.6 \text{ in}^3 \end{aligned}$$

---

[a] All figure numbers, section numbers, and nomenclature referenced in this appendix are taken from R. D. Finck, USAF Stability and Control DATCOM, October 1960 (Rev. January 1974), Flight Control Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio.

$$= 3.076 \text{ ft}^3$$

$$X_1 = 80 \text{ in} = 6.67 \text{ ft}$$

$$\frac{X_1}{\ell_B} = 1.0$$

$$\frac{X_o}{\ell_B} = 0.905 \text{ from Fig. 4.2.1.1-20b}$$

$$(K_2 - K_1) = 0.91 \text{ from Fig. 4.2.1.1-20a}$$

$$S_o = \frac{\pi}{4}(10)^2 = 78.54 \text{ in}^2 = 0.545 \text{ ft}^2$$

$$V_B{}^{2/3} = 3.076^{2/3} = 2.116 \text{ ft}^2$$

$$C_{L_\alpha} = \frac{(K_2 - K_1)\ S_o}{V_B{}^{2/3}} \quad \frac{2(.91)\ .545}{2.116}$$

$$= 0.469/\text{radian (based on } V_B{}^{2/3})$$

$$C_{L_\alpha} = 0.469 \times \frac{2.116}{.545}$$

$$= 1.82/\text{radian (based on } S_o)$$

Note that slender body theory would give $C_{L_\alpha} = 2$/radian. The control surfaces (or wings) with the hinge point at Station 78 are allowed to deflect freely during captive flight and therefore will produce no lift. It is further assumed that, since these surfaces will align themselves with the local flow direction, there will be no downwash to affect the lift of the forebody or afterbody. Consequently, the value of C_{L_α} for the forebody is:

$$\left(C_{L_\alpha}\right)_f = 1.82/\text{radian (based on } S_o)$$

The value of C_{L_α} for the afterbody will be difficult to determine because no method is available for a body of noncircular cross section. The lift of the inlet ducts cannot be treated in any straightforward manner. For lack of a precise method, it will be assumed that the inlet ducts produce the same lift as a low aspect ratio wing. However, it can be shown that the lift of the afterbody will be greater if the effect of the inlet ducts is neglected. This is because, by including the inlet ducts as an equivalent wing surface ahead of the fins, the aspect ratio of the combination is lower with a corresponding reduction in lift. Therefore, it will be assumed that the afterbody lift can be estimated by assuming the fin leading edge extends to the body. The method for calculating the lift of the wing-body combination follows the DATCOM method.

$$\left(C_{L_\alpha}\right)_{WB} = \left[K_N + K_{W(B)} + K_{B(W)}\right] \left(C_{L_\alpha}\right)_e \frac{S_e}{S_W}$$

Since the nose lift has been included as a forebody force, $K_N = 0$. (The values of $K_{W(B)}$ and $K_{B(W)}$ are found in Fig. 4.3.1.2-10, Appendix II .)

$$\frac{d}{b} = \frac{12}{32} = 0.375$$

$$K_{W(B)} + K_{B(W)} = 1.33 + 0.57 = 1.90$$

The value for $\left(C_{L_\alpha}\right)_e$ is found in DATCOM.

$$A = \frac{20}{20.7} = 0.97$$

$$\Lambda_{C/2} = 30^\circ$$

$$(M_{fb})_{\Lambda=0} = 1.0 \text{ from Fig. 4.1.3.2-43a}$$

$$(M_{fb})_{\Lambda} = 1.0 \text{ from Fig. 4.1.3.2-43b}$$

$$K = \frac{C_{L_\alpha}}{2\pi} \approx 1.0$$

$$\frac{A}{K}\left[\left(\beta_{fb}\right)_\Lambda^2 + \tan^2 \Lambda_{c/2}\right]^{\frac{1}{2}} = \frac{0.97}{1.0}(.577^2)^{\frac{1}{2}} = 0.560$$

$$\frac{C_{L_\alpha}}{A} = 1.55$$

$$\left(C_{L_\alpha}\right)_e = 1.55 \times .97 = 1.50$$

$$S_e = 2 \times 10 \times 8 + 12.7 \times 10 = 287 \text{ in}^2 = 1.99 \text{ ft}^2$$

$$\left(C_{L_\alpha}\right)_{WB} = \left[0 + 1.90\right] 1.50 \cdot \frac{1.99}{0.545} = 10.4/\text{radian (based on } S_o)$$

$$\left(C_{L_\alpha}\right)_a = 10.4/\text{radian (based on } S_o)$$

The value of C_{m_α} for the forebody will be calculated using the method in section 4.2.2.1 of DATCOM. The local body cross sectional area is required.

Station	Diameter, in.	S_x, ft^2	x, ft
0	0	0	0
4.5	5.0	0.136	0.375
9.5	6.5	0.230	0.792
22.5	9.6	0.503	1.875
32.0	10.0	0.545	2.667
80.0	10.0	0.545	6.667

This is plotted in Fig. C-1, from which dS/dx can be determined.

Station	dS_x/dx, ft
0 - 4.5	0.363
4.5 - 22.5	0.245
22.5 - 32.0	0.053
32.0 - 80.0	0.0

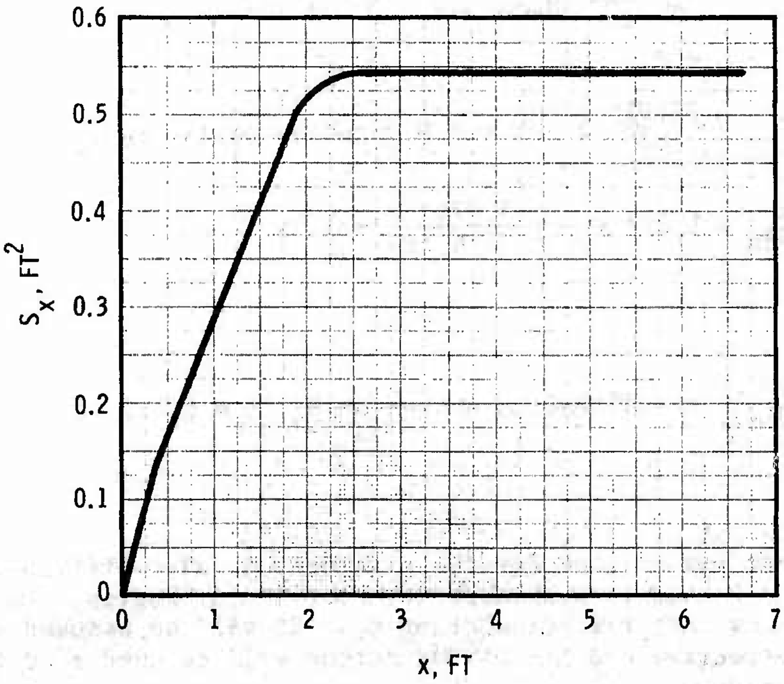


FIG. C-1. Forebody Cross Sectional Area Distribution.

The pitching moment curve slope, C_{m_α}, is found from

$$C_{m_\alpha} = \frac{2\ (K_2 - K_1)}{V_B} \int_o^{x_o} \frac{dS_x}{dx}\ (x_m - x)\, dx/\text{radian}$$

where x_m is location of moment center.

Piecewise Integration of Equation For C_{m_α}

Station	Δx	$(dS_x/dx)\Delta x$	x	(x_m-x)	$(dS_x/dx)(x_m-x)\ \Delta x$
0 - 4.5	0.375	0.136	0.187	6.48	0.881
4.5 - 22.5	1.500	0.368	1.125	5.54	2.039
22.5 - 32.0	0.792	0.042	2.667	4.00	0.168
32.0 - 80.0	4.000	0.0	-	-	0.0
					3.088

Note x_m at station 80.0

$$\sum_{x=o}^{x_o} \frac{dS_x}{dx}\ (x_m - x)\ \Delta x = 3.088\ ft^3$$

$$C_{m_\alpha} = \frac{2(.91)}{3.076}\ 3.088 = 1.827/\text{radian (based on } V_B)$$

$$C_{m_\alpha} = 1.827 \times \frac{3.076}{0.545 \times 6.667} = 1.55$$

$$\left(C_{m_\alpha}\right)_f = 1.55/\text{radian (based on } S_o,\ \ell = 6.667\ ft)$$

The pitching moment curve slope for the afterbody is also difficult to determine since no method is available for noncircular bodies. In keeping with the assumptions made for calculating C_{L_α}, it will be assumed that only the fin is effective and the DATCOM method will be used to determine the center of pressure.

$$\frac{X'_{a.c.}}{C_{r_e}} = \frac{\left(\frac{X'}{C_{r_e}}\right)_N C_{L_{\alpha_N}} + \left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{W(B)} C_{L_{\alpha_{W(B)}}} + \left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{B(W)} C_{L_{\alpha_{B(W)}}}}{C_{L\alpha_N} + C_{L\alpha_{W(B)}} + C_{L\alpha_{B(W)}}}$$

As before, the lift of the nose is included as a forebody force and $C_{L\alpha_N} = 0$.

$$C_{L\alpha_{W(B)}} = K_{W(B)} \left(C_{L\alpha}\right)_e \frac{S_e}{S_o}$$

$$C_{L\alpha_{B(W)}} = K_{B(W)} \left(C_{L\alpha}\right)_e \frac{S_e}{S_o}$$

The values of $K_{W(B)}$ and $K_{B(W)}$ are found in Fig. 4.3.1.2-10 of Appendix II.

$$C_{L\alpha_{W(B)}} = 1.33\ (1.50)\ \frac{1.99}{0.545} = 7.28$$

$$C_{L\alpha_{B(W)}} = 0.57\ (1.50)\ \frac{1.99}{0.545} = 3.12$$

The value of $\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{W(B)}$ is found from Fig. 4.1.4.2-22:

$$\lambda = \frac{8}{20.7} = 0.386$$

$$\frac{\beta}{\tan \Lambda_{LE}} = \frac{\sqrt{1-.8^2}}{\tan 52^o} = \frac{.6}{1.2799} = 0.46$$

$$A \tan \Lambda_{LE} = .97 \times 1.2799 = 1.24$$

$$\frac{X_{a.c.}}{C_r} = 0.3 = \left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{W(B)}$$

The value of $\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{B(W)}$ is found as outlined in Step 6 of Appendix IV.

$$\beta A_e = \sqrt{1-.8^2} \times 0.97 = 0.58$$

$$\frac{d}{b} = \frac{12}{20} = 0.6$$

$$\Lambda_{c/4} = 56^\circ$$

For $\beta A_e \geqslant 4.0$

$$\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{B(W)} = \frac{1}{4} + \frac{20 - 12}{2 \times 20.7} \tan 56^\circ \left[0.35\right] = 0.35$$

For $\beta A_e = 0$ and Figure 4.3.2.1-36b

$$\frac{1}{4}\left[A_e\ (1 + \lambda_e)\ \tan \Lambda_{LE}\right] = \frac{1}{4}\left[0.97(1.386)\ \tan 52^\circ\right] = 0.43$$

$$\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{B(W)} = 0.21$$

Interpolating gives

$$\left(\frac{X'_{a.c.}}{C_{r_e}}\right)_{B(W)} = 0.23$$

The center of pressure can now be calculated

$$\frac{\bar{X}'_{a.c.}}{C_{r_e}} = \frac{0 + 0.3 \times 7.28 + 0.23 \times 3.12}{0 + 7.28 + 3.12} = 0.279$$

The pitching moment curve slope for a moment center located at station 111.125 is

$$C_{m_\alpha} = C_{L\alpha} (Xm - X)/_{\ell} = 10.4 \times \frac{33.5 + 0.279 \times 20.7}{6.667 \times 12} = 5.11$$

$$\left(C_{m_\alpha}\right)_a = 5.11/\text{radian (based on } S_O,\ \ell = 6.667 \text{ ft)}$$

The aerodynamic forces and moments can now be calculated. The maximum aerodynamic loads are given below:

Point	L_f, lb	M_f, ft-lb	L_a, lb	M_a, ft-lb
2 or 6	273	1549	1559	5106

NOTE: L is the lift in lb normal to wind direction.
M is the moment in ft-lb.
f = forward.
a = aft.

It must be remembered that the aerodynamic loads given above are the maximum values. Since the values for α_S can be zero, it must be assumed that the aerodynamic loads can also be zero. The use of these loads in the structural analysis must consider the possibility of zero values and, therefore, selection of the worst case will be made during that analysis.

The values of $C_{L\alpha}$ and Cm_α are applicable to all points on the load diagram. Should it be necessary to evaluate loads at points other than 2 or 6, it is only necessary to determine the new value of α_S and evaluate the corresponding forces and moments.

Appendix D

GORJE FUEL TANK ASSEMBLY
(O&QR No. 1001)

OPERATIONS AND QUALITY RECORD

[x] O&QR [ ] CHANGE ORDER [ ] IDR PLAN [ ] OWR

REL. NO.	PAGE
1001	1

PART NO.	TITLE	QTY.	SERIAL NO.	PLAN REV.
C11225-01-02	Fuel Tank Assembly GORJE	1		N/C

PLANNER / DATE	ENGINEER / DATE	QUALITY ASSURANCE / DATE	NEXT ASSY-END ITEM
J. Sakoi 8-21-75	T. C. Warren 7-21-75	R. Higgs 8/28/75	Final

CONFIGURATION AUTHORITY	CHANGE ORDER RECORD	WOR NO.

OPER. NO.	OPERATIONS	COMPL. STAMP

GENERAL INSTRUCTIONS

A. This O&QR provides the documentation for the assembly of a GORJE tank assembly (C11225-01-02) for delivery to NWC.

B. Applicable Documents

Required ECOs

Drawings ECOs

C11225 Rev A — Fuel Tank Assembly GORJE

Information

Drawings

C11222 N/C — Hydrostatic Test Assembly Collector Pipe

C11223 N/C — Hydrostatic Test Assembly Fuel Tank

UTC-567 — Packaging Data Card (PDC) Form 2518

C. All operations performed per this O&QR shall be performed within the scope of the UTC Safety Manual.

D. All parts, components and materials shall have evidence of Quality Acceptance prior to issue.

E. Operator, Area Supervisor, or Quality Assurance, as applicable, shall stamp those operations indicated in the COMPL. STAMP or OPS. VER. columns.

F. Complete history sheet as applicable.

G. Upon completion of this O&QR, submit planning package to Acceptance Center.

UTC 3409A (11/67)

OPERATIONS AND QUALITY RECORD

CONTINUATION SHEET

REL. NO.	PAGE
1001	2 OF 3

PART NO.	PLAN REV.
C11225	N/C

OPER. NO.	OPERATIONS	COMPL. STAMP
10	Obtain parts and materials listed on configured parts list from stores.	
20	Verify that each part and material received is as specified, has a recorded QA document number (status tag No., log No., as required) and has no damaged parts. Record all serial numbers, lot numbers and status tag numbers on configured parts list.	
30	Inspect all expulsion tank parts for handling damage; e.g., O-ring sealing surfaces, tank I.D.	
40	Visually inspect bladder assembly (C11193) for any evidence of handling damage.	
50	Assemble two attach lugs per drawing C11225 using Items 10, 11, 12, 13, 14, 15, 16, 28, 29 and 32.	
60	Assemble collector pipe (C11210) to fuel tank (C11224) with screws, Item 27 of drawing C11225, for shipping only. Tighten screws finger tight.	
70	Identify fuel tank assembly P/N C11225-01-02, and applicable serial number per Note 1 of drawing C11225.	
80	Draw the following items from stores and package in kit form for shipment to customer.	

Print C11225

Qty	Item No.	Description
1	7	Bladder Assembly
1	18	Ring Retainer
24	26	Screws
2	33	Cotter Pin
2	34	Streamer Assembly
1	40	O-ring
1	41	O-ring
1	42	O-ring
12	43	Lock-O-Seal

OPER. NO.	OPERATIONS	COMPL. STAMP
90	QC verify identification and accountability.	
100	Deliver all components to Shipping Department for packaging in accordance with packaging data card 2518.	
110	Forward this O&QR to acceptance center.	

UTC 3409E (7/72)

OPERATIONS AND QUALITY RECORD
CONFIGURED PARTS LIST

REL. NO.	PAGE 3 OF 3
1001	

PART NO.	TITLE	QTY.	SERIAL NO.	PLAN REV.
C11225-01-02	Fuel Tank Assembly GORJE			

QTY.	PART NO.	PART NAME	DWG/SPEC. NO. AND REVISION	ENGINEERING CHANGE ORDERS	SERIAL NO. OR QC TRACE NO.	OPS. VER.
1	C11224-01-02	Tank, Fuel				
1	C11210-01-01	Collector Pipe Assy				
2	C11208-02-01	Retainer, Lug				
2	C11207-01-01	Lug, Suspension				
2	C11218-01-01	Shaft				
2	C11217-01-01	Sleeve				
2	C11208-01-01	Retainer, Lug				
2	C11215-01-01	Spring, Helical, Torsion				
2	C11216-01-02	Spring, Flat				
8		SCR, CAP, SCH, STL BLK Oxide, Flat 82° CSD, 1/4-28 UNF-2A x .50 Lg.				
2		SCR, CAP, Button Hd, STL BLK Oxide, 10-32 UNF-2A x .31 Lg.				
4		Screw Cap, Button Hd. STL, BLK Oxide 6-32 UNC-2A x 25 Lg.				
2	MS27183-8	Washer, Flat, Round, STL.				
AR		Grease per MIL-G-4343 or equiva.				
AR		Thread compound lubricant				

UTC 3409D (7/72)

FUEL TANK HYDROSTATIC TEST ASSEMBLY
(O&QR No. 1002)

OPERATIONS AND QUALITY RECORD

[X] O&QR [ ] CHANGE ORDER [ ] IDR PLAN [ ] OWR

REL. NO.	PAGE
1003	1

PART NO.	TITLE	QTY.	SERIAL NO.	PLAN REV.
C11222	Hydrostatic Test Assy - Collector Pipe	1		N/C

PLANNER / DATE	ENGINEER / DATE	QUALITY ASSURANCE / DATE	NEXT ASSY-END ITEM
J. Sakoi 8-29-75	T. C. Warren 9-2-75	R. Higgs 9/29/75	Final

CONFIGURATION AUTHORITY	CHANGE ORDER RECORD	WOR NO.

OPER. NO.	OPERATIONS	COMPL. STAMP

GENERAL INSTRUCTIONS

A. This O&QR provides the documentation for the hydrostatic test of a collector pipe assembly (C11210-01-01).

B. Applicable Documents

Required	ECOs	
Drawings	**ECOs**	
C11222 N/C		Hydrostatic Test Assembly Collector Pipe

C. All operations performed per this O&QR shall be performed within the scope of the UTC Safety Manual.

D. All parts, components and materials shall have evidence of Quality Acceptance prior to issue.

E. Operator, Area Supervisor, or Quality Assurance, as applicable, shall stamp those operations indicated in the COMPL. STAMP or OPS. VER. columns.

F. Complete history sheet as applicable.

G. Upon completion of this O&QR, submit planning package to Acceptance Center.

UTC 3409A (11/67)

OPERATIONS AND QUALITY RECORD

CONTINUATION SHEET

REL. NO.	PAGE 2 OF 4	PART NO.	PLAN REV.
1002		C11223	

OPER. NO.	OPERATIONS	COMPL. STAMP
10	Obtain parts and materials listed on configured parts list from stores.	
20	Verify that each part and material received is as specified, has a recorded QA document number (status tag. no., log no., as required) and has no damaged parts. Record all serial numbers, lot numbers and status tag numbers on configured parts list.	
30	Visually inspect o-ring surfaces for signs of abrasion, cuts, or other defects.	
40	Visually inspect all o-ring mating surfaces. Nicks, scratches, pits and tool marks are not allowed.	
50	Clean and lubricant all o-rings and o-ring surfaces with a thin coat of Parker o-ring lube or equivalent.	
60	Clean all screws and bolts of foreign material and apply a thin coat of lubricant.	
70	All items assembled per drawing C11223.	
80	Assemble item 10 to item 7 finger tight. Plug port in item 7 to be leak-proof. Install into item 6 using items 19 and 22.	
90	Assemble item 8 to item 6 using items 17 and 20. Torque item 17 to 10-12 in. lb.	
100	Assemble item 6 collector pipe C11210-01-01 tc item 5 fuel tank C11224-01-02 with items 16, 21. Torque item 16 to 100-120 in. lb.	
110	Install items 9 to fuel tank C11224-01-02 using item 15 torque to 23-30 in. lb.	
120	Fill tank with hydrostatic test fluid per C11223 note 6.	
130	Insert one AN-6 plug into on item 9 port.	
140	Connect pressure line to fuel tank to second item 9 port (pressure line to have manual cut-off valve).	
150	Position valve in off position.	
160	Place fuel tank in proof testing box. Connect pressure line to inside of thru-bulkhead fitting in box.	
170	Connect GN_2 bottle line to outside of testing box thru bulkhead fitting.	
180	Turn cut-off valve to "on" position.	
190	Increase pressure to 450 psig ± 10 psig for 15 to 30 seconds.	

UTC 3409E (7/72)

OPERATIONS AND QUALITY RECORD

CONTINUATION SHEET

REL. NO.	PAGE	PART NO.	PLAN REV.
1002	3 OF 4	C11223	

OPER. NO.	OPERATIONS	COMPL. STAMP
200	Leakage rate shall not be more than 2 psig per minute.	
210	QA verify ________________.	
220	Shut off pressure.	
230	Reduce pressure.	
240	Disassemble.	
250	Clean on dry components.	
260	Deliver to Development Center.	
270	MPI per Note 15 Dwg C01223.	
280	Return to Sunnyvale.	

UTC 3409E (7/72)

OPERATIONS AND QUALITY RECORD

CONFIGURED PARTS LIST

REL. NO.	PAGE 4 OF 4
1002	

PART NO.	TITLE	QTY.	SERIAL NO.	PLAN REV.
C11223	Fuel Tank - HYDROSTATIC TEST ASSY			

QTY.	PART NO.	PART NAME	DWG/SPEC. NO. AND REVISION	ENGINEERING CHANGE ORDERS	SERIAL NO. OR QC TRACE NO.	OPS. VER.
1	C11224-01-02	Fuel Tank				
1	C11210-01-01	Collector Pipe				
1	C11223-11-01					
1	C11223-12-01					
1	C11223-13-01					
1	C11223-14-01					
1	AN 932-3	Pipe Plug				
8		Screw, Soc Hd Cap, 1/4-28 UNF-2A x .62 Lg.				
4		Screw, Soc Hd Cap, 10-32 UNF-2A x .43 Lg.				
12		Screw, Soc Hd Cap, 4- 40 UNC-3A x .50 Lg.				
8		Washer, Flat, Stl., 1/4" Nom.				
1	N5000-250	Retaining Ring				
12	800-530-2	Lock-O-Seal				
1	2-248	O-Ring				
1	2-037	O-Ring				
2	2-014	O-Ring				
AR	DC-11	Grease or Equiv.				
AR	---	Thread Compound Lubricant				

UTC 3409D (7/72)

COLLECTOR PIPE HYDROSTATIC TEST ASSEMBLY
(O&QR No. 1003)

OPERATIONS AND QUALITY RECORD

[x] O&QR [ ] CHANGE ORDER [ ] IDR PLAN [ ] OWR

REL. NO.	PAGE
1002	1

PART NO.	TITLE	QTY.	SERIAL NO.	PLAN REV.
C11223-01-01	Hydrostatic Test Assy - Fuel Tank	1		N/C

PLANNER / DATE	ENGINEER / DATE	QUALITY ASSURANCE / DATE	NEXT ASSY-END ITEM
J. Sakoi 8-29-75	T. C. Warren 9-1-75	R. Higgs 8/29/75	Final

CONFIGURATION AUTHORITY	CHANGE ORDER RECORD	WOR NO.

OPER. NO.	OPERATIONS	COMPL. STAMP

GENERAL INSTRUCTIONS

A. This O&QR provides the documentation for the hydrostatic test of a fuel tank (C11224-01-01).

B. Applicable Documents

Required ECOs

No. 18873

C11223 N/C Hydrostatic Test Assembly Fuel Tank

C. All operations performed per this O&QR shall be performed within the scope of the UTC Safety Manual.

D. All parts, components and materials shall have evidence of Quality Acceptance prior to issue.

E. Operator, Area Supervisor, or Quality Assurance, as applicable, shall stamp those operations indicated in the COMPL. STAMP or OPS. VER. columns.

F. Complete history sheet as applicable.

G. Upon completion of this O&QR, submit planning package to Acceptance Center.

UTC 3409A (11/67)

OPERATIONS AND QUALITY RECORD

CONTINUATION SHEET

REL. NO.	PAGE	PART NO.	PLAN REV.
1003	3 OF 2		

OPER. NO.	OPERATIONS	COMPL. STAMP
10	Obtain parts and materials listed on configured parts list from stores.	
20	Verify that each part and material received is as specified, has a recorded QA document number (status tag. no., log no., as required) and has no damaged parts. Record all serial numbers, lot numbers and status tag numbers on configured parts list.	
30	Visually inspect o-ring surfaces for signs of abrasion, cuts, or other defects.	
40	Visually inspect all o-ring mating surfaces. Nicks, scratches, pits and tool marks are not allowed.	
50	Clean and lubricate all o-rings and o-ring surfaces with a thin coat of Parker o-ring lube or equivalent.	
60	Clean all screws and bolts of foreign material and apply a thin coat of lubricant.	
70	All items assembled per drawing C11222.	
80	Assemble item 6 to item 5 using items 9, 10 and 11. Torque item 9 to 10-12 in. lb.	
90	Fill item 5, collector pipe, thru port of item 6 with hydrostatic fluid per note 6.	
100	Plug one port of item 6 with plug AN-6 and connect pressure line to second port pressure line to have manual cut-off valve.	
110	Position valve in off position.	
120	Place collector pipe in proof testing box. Connect pressure line to inside of thru-bulkhead fitting in box.	
130	Connect GN_2 bottle line to outside of proof testing box thru-bulkhead fitting.	
140	Turn cut-off valve to "on" position	
150	Increase pressure to 100 psig ± 5 psig for 2 to 3 minutes. Leakage rate shall not be more than 2 psig per minute.	
160	QA verify ______________________.	
170	Shut off pressure.	
180	Reduce pressure.	
190	Disassemble, clean and dry components. Apply thin coating of protective oil.	

UTC 3409E (7/72)

OPERATIONS AND QUALITY RECORD
CONFIGURED PARTS LIST

PART NO.	TITLE	QTY.	SERIAL NO.	REL. NO.	PAGE 3 OF 3	PLAN REV.
C11222				1103		

QTY.	PART NO.	PART NAME	DWG/SPEC. NO. AND REVISION	ENGINEERING CHANGE ORDERS	SERIAL NO. OR QC TRACE NO.	OPS. VER.
1	C11210-01-01	Collector Pipe Assy				
1	C11222-11-01	Adapter				
12		Screw, Soc Hd. Cap, 40 UNC-3A x .50 Lg.				
12		Washer Flat, Nom. No. 4				
1	2-141	O-Ring				
AR	DC-11	Grease or Equiv.				
AR	--	Thread Compound Lubricant				

UTC 3409D (7/72)

Appendix E

FUEL TANK ASSEMBLY PACKAGING DATA CARD
(PDC 2518)

United Technology Center
SUNNYVALE, CALIF. 94086

UTC USE ONLY

SPECIFICATION NO.	FIGURE A	SHEET 1 OF	PROGRAM NO.	REV.
N/A	N/A		2518	

PACKAGING DATA CARD (PDC)

ITEM IDENTIFICATION DATA

FED. STK. NO.: N/A

NOMENCLATURE: TANK, FUEL, ASSY (GORJE)

UTC P N (SEE NOTE-2): C11225

CONTRACT NO.: N/A

PROGRAM NO.: N/A

PROJECT NO.: N/A

CHARACTERISTICS:
- [X] STURDY
- [ ] FRAGILE
- [ ] ELECTRICAL
- [ ] CORROSIVE
- [ ] OXIDIZING
- [ ] FLAMMABLE
- [ ] LIQUID
- [ ] SOLID
- [ ] COMPRESSED GAS
- [ ] POISON A B C D
- [ ] EXPLOSIVE A B C

MATERIAL: VARIOUS

FINISH: BARE

NET WT. LBS.: 62

L 31.0 IN; W --- IN; H --- IN; DIA 12.0 IN

MFG. P N: N/A

VENDOR P N: N/A

PREPARED	DATE	APPROVED	DATE
W. HAMMOND	4-29-75	[signature]	4-29-75
CHECKED [signature]	4-29-5	APPROVED	

PRESERVATION AND PACKAGING DATA - CODED PER MIL-STD-726

1-2 PRESERVATION METHOD	3 QTY UNIT PACK	4 CLN AND DRY	5-6 PRESERVATION MATERIAL	7-8 WRAPPING MATERIAL	9-10 CUSHION AND DUNNAGE	11 CUSH THICKNESS	12-13 UNIT PACKAGE	14 INTR CONT QTY	15-16 INTERIM CONTAINER	17 LEVEL OF PROT
10	1	Z	00	00	ZZ	Z	ZZ	0	00	B
10	1	Z	00	00	ZZ	Z	ZZ	0	00	C

MATERIAL SUBSTITUTION PERMITTED

Material must be equal to or better than those specified above, must provide equal or better protection, must not impair function, must be in accordance with current Air Force Bulletin No. 56, meet the requirements of specification MIL-P-116 and be furnished at an equal or lower cost.

NOTES:

1. MARKING FOR SHIPMENT AND STORAGE PER MIL-STD 129.
2. THIS PDC IS APPLICABLE TO ALL DASH NUMBERS: THE TANK ASSY WILL BE PACKAGED WITH THE COLLECTOR PIPE, P/N C11210 INSTALLED INTO THE FUEL TANK, P/N C11224, WITH C11225, ITEM-27 FLAT HEAD SCREWS. THE BLADDER ASSY, P/N C11193, AND OTHER LOOSE HARDWARE WILL BE SEPARATELY BAGGED AND PACKED INTO THE SHIPPING CONTAINER.
3. DIGIT-4: THE ITEMS SHALL BE THOROUGHLY CLEAN AND FREE OF ANY FOREIGN MATTER.
4. DIGIT 5-6 & 7-8: THE TANK OUTSIDE SURFACE SHALL BE COATED WITH TEXACO RUST-PROOF AND SHALL BE WRAPPED WITH A GREASE-PROOF BARRIER MATERIAL TO PREVENT PRESERVATIVE FROM BEING WIPED OFF.
5. BLADDER ASSY. THE BLADDER ASSY SHALL BE PLACED INTO A PLASTIC BAG/WRAP, TAPED CLOSED, AND PLACED ON TOP OF THE PACKED FUEL TANK (SEE NOTE-8).
6. LOOSE HARDWARE. LOOSE HARDWARE SHALL BE SEPARATELY BAGGED, BY LIKE ITEM, AND THE BAG SHALL BE MARKED WITH THE CONTENTS PART NUMBER, DESCRIPTION, AND QUANTITY OF ITEMS THEREIN. THESE BAGGED ITEMS SHALL BE PLACED INTO THE SHIPPING BOX WITH THE FUEL TANK.
7. DIGIT 12-13: THE SHIPPING BOX SHALL BE A STRONG WOODEN BOX SIZED TO ACCEPT THE FUEL TANK, BLADDER, AND LOOSE HARDWARE, CUSHIONED ALL AROUND TO PREVENT ANY MOVEMENT/DAMAGE TO THE PARTS THEREIN (SEE NOTE-8).
8. ITEM PACKING. THE SHIPPING BOX SHALL BE LINED WITH CELLULOSIC SHEET CUSHIONING MATERIAL/BUBBLE-PACK SHEET CUSHIONING MATERIAL TO PROVIDE A COMPLETE WRAP-AROUND THE FUEL TANK. BLOCK TANK TO PREVENT MOVEMENT. THE BAGGED BLADDER AND LOOSE HARDWARE SHALL BE PLACED IN THE TOP OF THE BOX.

UTC-567 (4/69)

PACKAGI ` DATA CARD SKETCH SHEET

SHEET 2 OF 2	
DRW NO.	REV.
2518	

NOMENCLATURE

TANK, FUEL, ASSY (GORJE)

9. BOX MARKING: THE FOLLOWING INFORMATION SHALL BE STENCILED ON THE SHIPPING BOX:

P/N C11225
TANK, FUEL, ASSY-GORJE
1-EA.
S/N (Add)
WT (Add)
PROJ. NO. (Add)
CONTR. NO. (Add)

QTY. REQ'D	DET.	DESCRIPTION

UTC-567A (4/69)

Appendix F

TANK AND BLADDER TEST LOGS

TEST RESULTS

GORJE TANK ASSEMBLY

Part Number	Serial Number	Page Numbers
C11225-01-01	001	171 to 178
C11225-01-01	002	179 to 186
C11225-01-02	003	187 to 193
C11225-01-02	004	194 to 200
C11225-01-02	005	201 to 213

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-01	001	N/C	None
Fuel Tank	C11224-01-01	001	A	None
Collector Pipe	C11210-01-01	001	A	18851, 18869
Bladder Assembly	C11193-01-01	003	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-01	N/A	N/C	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank Serial No. 001

Event	Date
1. Completion Date of Fuel Tank	1/21/75
2. Acceptance Date of Fuel Bladder	1/18/75
3. Completion Date of Collector Pipe	1/15/75
4. Hydrotest Date of Collector Pipe	1/22/75
5. Hydrotest Date of Fuel Tank	1/22/75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-off)	1/23/75

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1. Bladder S/N	003	
2. Bladder Weight	3.56 LB	
3. Bladder Test Date	1/23/75	
4. Test Conductor	J. SAKOI	
5. Bladder Test Tank	N/A	
6. Bladder Fitup	☑ Acceptable ☐ Unacceptable	
7. Leak Test Gas	GN2	
8. Bladder Side Pressurized	☑ Interior ☑ Exterior	
9. Bladder Leak Test Pressure	15	psi
10. Bladder Leakage Rate	NONE	psi/min
11. Number of Bladder Expulsion Cycles	NONE	
12. Test Conductor Signature	[signature]	
13. Q.A. Observer Signature	[signature] FOR R. HAAS	
14. AFPRO Observer Signature	N/A TW	

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No. C11223-01-01

Serial No. 001

Date 22Jan75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of UTC drawing C11223, and was found to be acceptable to United Technology Center.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum) 48.0 lbs

R. M. [illegible] 1/23/75
(UTC Quality Assurance)

GORJE FUEL TANK COLLECTOR PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1. Collector Pipe S/N	001	
2. Collector Pipe Weight	11.0	lbs
3. Collector Pipe Capacity	[illegible]	in^3
4. Test Date	1-22-75	
5. Test Conductor	J. SAKAI	
6. Test Location	RM 195 BLDG 5200	
7. Test Fluid	H_2O	
8. Test Pressurant	GN_2	
9. Proof Test Pressure	100	psi
10. Proof Test Pressure Duration	3	min
11. Leakage Rate	< 1.5 (FACILITY LEAK)	psi/min
12. Test Conductor Signature	[illegible]	
13. ~~MPI~~ NDT Inspection Results	[illegible] (ACCEPTABLE PER [illegible])	
14. Q.A. Observe Signature	[illegible] 1/22/75	
15. AFPRO Observe Signature	N/A (FOR FLIGHT TEST TANKS ONLY)	

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01 01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	001	
2.	Tank Weight (WITH LUGS & PAINT)	47.5	lbs
3.	Test Date	1-22-75	
4.	Test Conductor	J. SAKUI [illegible]	
5.	Test Location	RM 195 BLDG 5200	
6.	Test Fluid	H_2O + 5% SOLUBLE OIL	
7.	Tank Capacity	2389	in^3 EQUIV TO 74.93 lbs of TH DIMER
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	455	psi
10.	Proof Test Pressure Duration	30 SEC	~~min~~
11.	Leakage Rate	—	psi/min
12.	MPI Inspection Results	ACCEPTABLE [illegible]	
13.	Q.A. Observe Signature	[illegible]	
14.	AFPRO Observe Signature.	N/A (STRUCTURAL TEST)	

UTC 23 1-23-75

NDT REPORT

GORJE Fuel Tank

Part No. C11225-01-01

Serial No. 001

Date 23Jan75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to United Technology Center.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to United Technology Center.

R. M. Briggs 1/23/75
(UTC Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit acceptable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg.Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-01	002	A	None
Fuel Tank	C11224-01-02	002	B	18969, 18987
Collector Pipe	C11210-01-01	005	A	18851, 18869
Bladder Assembly	C11193-01-01	008	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Retainer, Lug	C11208-02-01	N/A	A	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A	A	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank Serial No. 002

Event	Date
1. Completion Date of Fuel Tank	1/21/75
2. Acceptance Date of Fuel Bladder	4/16/75
3. Completion Date of Collector Pipe	4/7/75
4. Hydrotest Date of Collector Pipe	4/11/75
5. Hydrotest Date of Fuel Tank	4/16/75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-off)	4/24/75

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	- 008	
2.	Bladder Weight	3.50 LBS.	
3.	Bladder Test Date	4-16-75	
4.	Test Conductor	DC Bonk.	
5.	Bladder Test Tank	Prey.	
6.	Bladder Fitup	☑ Acceptable ☐ Unacceptable	
7.	Leak Test Gas	GN_2	
8.	Bladder Side Pressurized	☐ Interior ☑ Exterior	
9.	Bladder Leak Test Pressure	30 - HOLD AT 15	psi
10.	Bladder Leakage Rate	None.	psi/min
11.	Number of Bladder Expulsion Cycles	—	
12.	Test Conductor Signature	[signature]	
13.	Q.A. Observer Signature	[signature]	
14.	AFPRO Observer Signature	N/A Waived By W. Smith (this unit only) [signature]	

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No. C11223-01-01

Serial No. 002

Date 22 Apr 75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of UTC drawing C11223, and was found to be acceptable to United Technology Center.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)	47.8 lbs

R. N. [illegible]

(UTC Quality Assurance)

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1. Collector Pipe S/N	005	
2. Collector Pipe Weight	10.50	lbs
3. Collector Pipe Capacity	—	in^3
4. Test Date	4-11-75	
5. Test Conductor	D. BONK	
6. Test Location	BLDG 5000 RM 275	
7. Test Fluid	WATER	
8. Test Pressurant	GN_2	
9. Proof Test Pressure	100	psi
10. Proof Test Pressure Duration	2.5	min
11. Leakage Rate	0	psi/min
12. Test Conductor Signature	[signature]	
13. NDT Inspection Results	Acceptable	
14. Q.A. Observe Signature	[signature]	
15. AFPRO Observe Signature	N/A - waived this unit only. [signature]	

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	-002	
2.	Tank Weight	45.5 *	lbs
3.	Test Date	4-16-75	
4.	Test Conductor	DC [illegible]	
5.	Test Location	- SV.	
6.	Test Fluid	[illegible] OIL	
7.	Tank Capacity	2355 **	in^3
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	460 —	psi
10.	Proof Test Pressure Duration	30 [illegible]	min
11.	Leakage Rate	None	psi/min
12.	MPI Inspection Results	ACCEPTABLE	
13.	Q.A. Observe Signature	R.M. [illegible]	
14.	AFPRO Observe Signature.	N/A - WAIVED THIS [illegible] ONLY PER W. SMYTH. [illegible]	

* WITHOUT ATTACH LUGS

** EQUIVALENT TO 75.82 lbs OF TH DIMER @ 140°F

NDT REPORT

GORJE Fuel Tank

Part No. C11225-01-01

Serial No. 002

Date 4/18/75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to United Technology Center.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to United Technology Center.

(UTC Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit acceptable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-02	003	A	None
Fuel Tank	C11224-01-02	003	B	19378
Collector Pipe	C11210-01-01	003	A	18851, 18869, 18875
Bladder Assembly	C11193-01-01	010	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Retainer, Lug	C11208-02-01	N/A	A	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A	A	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank Serial No. 003

Event	Date
1. Completion Date of Fuel Tank	8-8-75
2. Acceptance Date of Fuel Bladder	4-18-75
3. Completion Date of Collector Pipe	5-28-75
4. Hydrotest Date of Collector Pipe	9-5-75
5. Hydrotest Date of Fuel Tank	9-8-75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-Off)	9-26-75

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No. C11223-01-01

Serial No. 003

Date 9-8-75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)	44.5 lbs

R. N. Hoggatt 9/20/75

(CSD Quality Assurance)

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	3	
2.	Collector Pipe Weight	9.98	lbs
3.	Collector Pipe Capacity	N/A	in^3
4.	Test Date	9-5-75	
5.	Test Conductor	J.S. SAKOI	
6.	Test Location	SV	
7.	Test Fluid	H_2O/SOL. OIL	
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	104	psi
10.	Proof Test Pressure Duration	2	min
11.	Leakage Rate	NONE	psi/min
12.	Test Conductor Signature	J Sakoi	
13.	NDT Inspection Results	NOT APPLICABLE	
14.	Q.A. Observe Signature	[illegible]	
15.	AFPRO Observe Signature	N/A	

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	3	
2.	Tank Weight	44.5	lbs
3.	Test Date	9-8-75	
4.	Test Conductor	J. SAKOI	
5.	Test Location	SV	
6.	Test Fluid	H_2O/SOL. OIL	
7.	Tank Capacity	2350	in^3
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	450	psi
10.	Proof Test Pressure Duration	1/2	min
11.	Leakage Rate	2	psi/min
12.	MPI Inspection Results	12 UTC 9-10-75	
13.	Q.A. Observe Signature	[illegible]	
14.	AFPRO Observe Signature.	N/A	

NDT REPORT

GORJE Fuel Tank

Part No. C11225-01-02

Serial No. 003

Date 9-18-75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

R. M. [illegible] 9/26/75
(CSD Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit acceptable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-02	004	A	None
Fuel Tank	C11224-01-02	004	B	19378
Collector Pipe	C11210-01-01	004	A	18851, 18869, 18875
Bladder Assembly	C11193-01-01	011	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Retainer, Lug	C11208-02-01	N/A	A	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A	A	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank Serial No. 004

Event	Date
1. Completion Date of Fuel Tank	8-8-75
2. Acceptance Date of Fuel Bladder	4-18-75
3. Completion Date of Collector Pipe	5-28-75
4. Hydrotest Date of Collector Pipe	9-5-75
5. Hydrotest Date of Fuel Tank	9-8-75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-Off)	9-26-75

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No. C11223-01-01

Serial No. 004

Date 9-8-75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)	44.7 lbs

R. M. [illegible] 9/26/75
(CSD Quality Assurance)

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1.	Collector Pipe S/N	5	
2.	Collector Pipe Weight	10.44	lbs
3.	Collector Pipe Capacity	N/A	in^3
4.	Test Date	9-5-75	
5.	Test Conductor	J. S. Sakoi	
6.	Test Location	SV	
7.	Test Fluid	H_2O/SOL. OIL	
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure (100 psig)	102	psi
10.	Proof Test Pressure Duration	2 1/2	min
11.	Leakage Rate	NONE	psi/min
12.	Test Conductor Signature	J Sakoi	
13.	NDT Inspection Results	NOT APPLICABLE	
14.	Q.A. Observe Signature	E.M. Hayes	
15.	AFPRO Observe Signature	N/A	

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	4	
2.	Tank Weight	44.7	lbs
3.	Test Date	9-8-75	
4.	Test Conductor	J. SAKOI [signature]	
5.	Test Location	SV	
6.	Test Fluid	H_2O / SOL. OIL	
7.	Tank Capacity	2350	in^3
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	450	psi
10.	Proof Test Pressure Duration	1/2	min
11.	Leakage Rate	2	psi/min
12.	MPI Inspection Results	[stamp: 12 UTC] 9-18-75	
13.	Q.A. Observe Signature	[signature]	
14.	AFPRO Observe Signature.	N/A	

NDT REPORT

GORJE Fuel Tank

Part No. C11225-01-02

Serial No. 004

Date 9-18-75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

R. N. [illegible] 9/26/75
(CSD Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit acceptable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

CONFIGURATION SUMMARY / DETAILED PARTS LIST

Component	Part No.	Serial No.	Dwg Rev.	Applicable ECO's
GORJE Tank Assembly	C11225-01-02	005	A	None
Fuel Tank	C11224-01-02	005	B	19378
Collector Pipe	C11210-01-01	006	A	18851, 18869, 18875
Bladder Assembly	C11193-01-01	012	A	None
Lug, Suspension	C11207-01-01	N/A	N/C	None
Sleeve	C11217-01-01	N/A	N/C	None
Shaft	C11218-01-01	N/A	N/C	None
Retainer, Lug	C11208-01-01	N/A	A	None
Retainer, Lug	C11208-02-01	N/A	A	None
Spring, Helical, Torsion	C11215-01-01	N/A	N/C	None
Spring, Flat	C11216-01-02	N/A	A	None
Ring, Retainer	C11219-01-01	N/A	N/C	None

CHRONOLOGY OF MANUFACTURING HISTORY

Fuel Tank Serial No. 005

Event	Date
1. Completion Date of Fuel Tank	8-8-75
2. Acceptance Date of Fuel Bladder	4-21-75
3. Completion Date of Collector Pipe	5-28-75
4. Hydrotest Date of Collector Pipe	9-5-75
5. Hydrotest Date of Fuel Tank	9-8-75
6. GORJE Tank Assembly Acceptance Date (DD-250 Sign-Off)	9-26-75

HYDROSTATIC TEST REPORT / WEIGHT SUMMARY

Part No. C11223-01-01

Serial No. 005

Date 9-8-75

This is to certify that the above Fuel Tank was hydrostatic tested in accordance with the requirements of CSD drawing C11223, and was found to be acceptable to Chemical Systems Division of United Technologies.

Tank Weight (without bladder and collector pipe - must be 51 lbs maximum)	44.7 lbs

R. M. [illegible] 9/26/75
(CSD Quality Assurance)

NWC TP 5835

GORJE FUEL TANK COLLECTOR

PIPE HYDROTEST DATA SHEET

2516-001

Contract: N00123-74-C-1337

UTC Project No. 2516

PROOF TEST COLLECTOR PIPE ASSEMBLY

P/N C11210-01-01 Per UTC D/N C11222

1. Collector Pipe S/N	6	
2. Collector Pipe Weight	10.08	lbs
3. Collector Pipe Capacity	N/A	in^3
4. Test Date	9-5-75	
5. Test Conductor	J.S. SAKOI	
6. Test Location	SV	
7. Test Fluid	H_2O / SOL. OIL	
8. Test Pressurant	GN_2	
9. Proof Test Pressure	100	psi
10. Proof Test Pressure Duration	2 1/2	min
11. Leakage Rate	NONE	psi/min
12. Test Conductor Signature	J Sakoi	
13. NDT Inspection Results	NOT APPLICABLE	
14. Q.A. Observe Signature	R.M. [illegible]	
15. AFPRO Observe Signature	N/A	

GORJE FUEL TANK

HYDROTEST DATA SHEET

2516-002

Contract N00123-74-C-1337

UTC Project No. 2516

PROOF TEST FUEL TANK P/N C11224-01-01

per UTC Hydrostatic Test Assembly D/N C11223

1.	Tank S/N	5	
2.	Tank Weight	44.7	lbs
3.	Test Date	9-8-75	
4.	Test Conductor	J. Sakoi J Sakoi	
5.	Test Location	SJ	
6.	Test Fluid	H_2O/Sol. Oil	
7.	Tank Capacity	2350	in^3
8.	Test Pressurant	GN_2	
9.	Proof Test Pressure	450	psi
10.	Proof Test Pressure Duration	1/2	min
11.	Leakage Rate	2	psi/min
12.	MPI Inspection Results	12 UTC 9-18-75	
13.	Q.A. Observe Signature	[illegible]	
14.	AFPRO Observe Signature.	N/A	

NDT REPORT

GORJE Fuel Tank

Part No. C11225-01-02

Serial No. 005

Date 9-18-75

This Fuel Tank was magnetic particle inspected in accordance with drawing note 4 of drawing C11224 before hydrostatic test, and per drawing note 15 of drawing C11223 after hydrostatic test, and was found to be acceptable to Chemical Systems Division of United Technologies.

All other miscellaneous components which are part of the assembled Fuel Tank were examined by NDT in accordance with the applicable drawings, and were found to be acceptable to Chemical Systems Division of United Technologies.

R. N. [illegible] 9/26/75

(CSD Quality Assurance)

INTERFACE FEATURE REPORT

Inspection Points	Results
o Forward Skirt Inspection	Acceptable to drill jig
o Aft Skirt Inspection	Acceptable to drill jig
o Forward Dome Boss to Bladder Fitting	Functional fit acceptable
o Aft Dome Boss to Collector Pipe	Functional fit acceptable
o Bladder to Tank Assembly	Functional fit acceptable
o Attach Lugs to Tank Longeron	Functional fit acceptable

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1. Bladder S/N 002
2. Bladder Weight 3.7
3. Bladder Test Date 4-21-75
4. Test Conductor [illegible]
5. Bladder Test Tank Plexiglass
6. Bladder Fitup ☒ Acceptable ☐ Unacceptable
7. Leak Test Gas GN2
8. Bladder Side Pressurized ☐ Interior ☒ Exterior
9. Bladder Leak Test Pressure 25-15 psi
10. Bladder Leakage Rate None psi/min
11. Number of Bladder Expulsion Cycles ______
12. Test Conductor Signature [illegible]
13. Q.A. Observer Signature ______
14. AFPRO Observer Signature ______

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	004
2.	Bladder Weight	3.22 LBS
3.	Bladder Test Date	4-18-75
4.	Test Conductor	[illegible]
5.	Bladder Test Tank	[illegible] Tank
6.	Bladder Fitup	☒ Acceptable ☐ Unacceptable
7.	Leak Test Gas	GN_2
8.	Bladder Side Pressurized	☐ Interior ☒ Exterior
9.	Bladder Leak Test Pressure	25-15 psi
10.	Bladder Leakage Rate	None psi/min
11.	Number of Bladder Expulsion Cycles	
12.	Test Conductor Signature	[illegible]
13.	Q.A. Observer Signature	
14.	AFPRO Observer Signature	

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1. Bladder S/N	0055	
2. Bladder Weight		
3. Bladder Test Date	30 JAN 75	
4. Test Conductor	J. S. SAKOI	
5. Bladder Test Tank	PLEXIGLASS TANK	
6. Bladder Fitup	☐ Acceptable ☐ Unacceptable	
7. Leak Test Gas	GN_2	
8. Bladder Side Pressurized	☐ Interior ☒ Exterior	
9. Bladder Leak Test Pressure	40	psi
10. Bladder Leakage Rate	1/2 PSI	psi/min
11. Number of Bladder Expulsion Cycles	—	
12. Test Conductor Signature	J. S. Sakoi	
13. Q.A. Observer Signature		
14. AFPRO Observer Signature		

Bladder has blisters on outside surface.

NWC TP 5835

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	025	
2.	Bladder Weight	3.25	
3.	Bladder Test Date	4-21-75	
4.	Test Conductor	[illegible]	
5.	Bladder Test Tank	[illegible]	
6.	Bladder Fitup	☒ Acceptable ☐ Unacceptable	
7.	Leak Test Gas	GN2	
8.	Bladder Side Pressurized	☐ Interior ☒ Exterior	
9.	Bladder Leak Test Pressure	25 - 15	psi
10.	Bladder Leakage Rate	None	psi/min
11.	Number of Bladder Expulsion Cycles		
12.	Test Conductor Signature	[illegible]	
13.	Q.A. Observer Signature		
14.	AFPRO Observer Signature		

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	007 (ALSO 007S)
2.	Bladder Weight	3.31 LB.
3.	Bladder Test Date	5 FEB 75
4.	Test Conductor	J. S. SAKOI
5.	Bladder Test Tank	PLEXIGLASS TANK
6.	Bladder Fitup	☒ Acceptable ☐ Unacceptable
7.	Leak Test Gas	
8.	Bladder Side Pressurized	☐ Interior ☒ Exterior
9.	Bladder Leak Test Pressure	17 PSI ~~40~~ 30 psi
10.	Bladder Leakage Rate	* psi/min
11.	Number of Bladder Expulsion Cycles	
12.	Test Conductor Signature	[illegible]
13.	Q.A. Observer Signature	
14.	AFPRO Observer Signature	

* 15 PSI @ 10:50 AM 6 FEB 1 min Hold. - No leak visible

* 30 PSI 2 air bubbles per min approx size 1/2 Dia

NWC TP 5835

GORJE FUEL TANK

BLADDER LEAK TEST & FUNCTIONAL FIT DATA SHEET

2516-003

Contract N00123-74-C-1337

UTC Project No. 2516

BLADDER ASSEMBLY P/N C11193-01-01

1.	Bladder S/N	009
2.	Bladder Weight	3.43 LBS.
3.	Bladder Test Date	4-18-75
4.	Test Conductor	D C Bowk
5.	Bladder Test Tank	Plexiglass Tank
6.	Bladder Fitup	☒ Acceptable ☐ Unacceptable
7.	Leak Test Gas	air
8.	Bladder Side Pressurized	☐ Interior ☒ Exterior
9.	Bladder Leak Test Pressure	30 - 15 psi
10.	Bladder Leakage Rate	None psi/min
11.	Number of Bladder Expulsion Cycles	—
12.	Test Conductor Signature	[illegible]
13.	Q.A. Observer Signature	
14.	AFPRO Observer Signature	

INITIAL DISTRIBUTION

13 Naval Air Systems Command
- AIR-03B (1)
- AIR-03P2 (1)
- AIR-30212 (2)
- AIR-320C, W. Volz (1)
- AIR-330F (1)
- AIR-503 (1)
- AIR-503E (1)
- AIR-5108 (1)
- AIR-5109 (1)
- AIR-5203 (1)
- AIR-5351 (1)
- AIR-5366 (1)

3 Chief of Naval Material
- MAT-030B (1)
- MAT-032 (1)
- NSP-27 (1)

2 Naval Sea Systems Command
- SEA-0332 (1)
- SEA-04H (1)

1 Air Test and Evaluation Squadron 5 (LT Karl Kail)

1 Naval Ammunition Depot, Hawthorne (Code 05, Robert Dempsey)

1 Naval Explosive Ordnance Disposal Facility, Indian Head

1 Naval Intelligence Support Center (OOXA, CDR Jack Darnell)

1 Naval Ship Research and Development Center, Bethesda (Code 166, John F. Talbot)

1 Naval Surface Weapons Center, White Oak (Code 312, W. C. Ragsdale)

1 Naval Undersea Center, San Diego (Code 133)

1 Naval Intelligence Support Center Liaison Officer (LNN)

1 Army Armament Command, Rock Island Arsenal (AMSAR-SF)

1 Army Missile Command, Research and Development Directorate, Redstone Arsenal (AMSMI-RK, Dr. R. G. Rhoades)

4 Picatinny Arsenal (SMD, Concepts Branch)

3 Air Force Systems Command, Andrews Air Force Base
- DLFP (1)
- DLW (1)
- SDW (1)

5 Air Force Armament Laboratory, Eglin Air Force Base
- DLD (1)
- DLJW (1)
- DLO (1)
- DLQ (1)
- DLR (1)

1 Foreign Technology Division, Wright-Patterson Air Force Base (Code PDXA, James Woodard)

5 Wright-Patterson Air Force Base
  AFAPL
    RJA (1)
    RJT (1)
  STINSO (1)
  XRDP (1)
  XRHP (1)
1 Defense Advanced Research Projects Agency, Arlington
2 Defense Documentation Center
1 Explosives Safety Board (6-A-145)
1 Applied Physics Laboratory, JHU, Laurel, Md. (W. B. Shippen)
1 Beech Aircraft Corporation, Whichita, Kan.
1 Convair Division of General Dynamics, San Diego, Calif.
1 Grumman Aerospace Corporation, Bethpage, N.Y.
1 Honeywell Inc., Systems & Research Division, Minneapolis, Minn.
1 Hughes Aircraft Company, Culver City, Calif.
1 Hughes Aircraft Company, Missiles Systems Division, Canoga Park, Calif.
1 McDonnell Douglas Corporation, St. Louis, Mo. (Astronautics, A. N. Thomas)
1 Marquardt Corporation, Van Nuys, Calif.
1 North American Rockwell Corporation, Columbus, Ohio (R. C. Wykes)
1 Purdue University, School of Mechanical Engineering, Lafayette, Ind. (Cecil F. Warner)
1 Ryan Aeronautical Company, San Diego, Calif.
1 The Boeing Company, Seattle, Wash.
1 The Martin Company, Orlando, Fla.
1 United Aircraft Corporation, East Hartford, Conn. (Research Laboratories, R. L. O'Brien)
101 Chemical Propulsion Mailing List No. 271 dated October 1975, including Categories 1,2,3,4,5